



**NRG Potomac River LLC**  
8301 Professional Place  
Suite 230  
Landover, MD 20785

September 5, 2014

Mr. Alex Wardle  
13901 Crown Court  
Woodbridge, VA 22193

RE: Potomac River Generating Station, Alexandria, Virginia

Dear Mr. Wardle:

Please find attached the Corrective Action Plan for the subject facility. If you have any questions regarding this matter, please do not hesitate to contact me at (678)641-2503, or by email at [burt.mccullough@nrgenergy.com](mailto:burt.mccullough@nrgenergy.com).

Sincerely,

A handwritten signature in black ink, appearing to read 'Burt McCullough'. The signature is stylized with a large 'B' and a long, sweeping underline.

Burt McCullough  
Director, Environmental Remediation

## **Corrective Action Plan**

**Potomac River Generating Station  
1400 N. Royal Street  
Alexandria, VA**

*Prepared for:*

**NRG Potomac River LLC**  
1400 N. Royal Street  
Alexandria, VA 22314

*Prepared by:*



**GROUNDWATER & ENVIRONMENTAL SERVICES, INC.**

1350 Blair Drive, Suite A  
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*and*



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September 5, 2014



## TABLE OF CONTENTS

<b>1.0</b>	<b>INTRODUCTION.....</b>	<b>1</b>
1.1	Background.....	1
<b>2.0</b>	<b>SITE DESCRIPTION / FACILITY BACKGROUND.....</b>	<b>2</b>
2.1	Physical Setting.....	2
2.2	Facility Description.....	3
2.3	Regional Geologic Setting.....	5
2.4	Fuel Oil UST Testing, Inspection and Repair Summary .....	6
<b>3.0</b>	<b>SUMMARY OF PREVIOUS INVESTIGATIONS .....</b>	<b>8</b>
<b>4.0</b>	<b>ADDITIONAL SITE ASSESSMENT AND INTERIM ACTIONS FOR CAP DEVELOPMENT .....</b>	<b>9</b>
4.1	Introduction.....	9
4.2	Bulkhead/Pump House Assessment.....	9
4.3	Ongoing Liquid Level Monitoring.....	10
4.4	Tidal Influences .....	10
4.5	Additional Soil Delineation .....	11
4.6	Additional Groundwater Delineation.....	14
4.7	Interim Recovery Actions / Pumping Study .....	18
4.8	Bulkhead Integrity Assessment and Seep Sampling.....	24
<b>5.0</b>	<b>HYDROGEOLOGY / CONCEPTUAL SITE MODEL.....</b>	<b>25</b>
5.1	Site Geology .....	25
5.2	Site Hydrogeology .....	26
5.3	Structural Barriers and Pathways.....	28
5.4	Identified Preferential Pathways .....	29
<b>6.0</b>	<b>REMEDIALATION ASSESSMENT.....</b>	<b>29</b>
6.1	Bulkhead Seep Sealing .....	30
6.2	Pump & Treat (P&T) or Total Fluid Extraction (TFE).....	30
6.3	Soil Vapor Extraction (SVE) .....	30
6.4	Vacuum Enhanced Groundwater Extraction (VEGE) .....	31
6.5	Air Sparge / Soil Vapor Extraction (AS/SVE).....	31
6.6	Biosparge / Aerobic Bioremediation .....	32
6.7	Soil Excavation .....	32
6.8	Bioslurping.....	33
6.9	Enhanced Fluid Recovery (EFR) .....	33
6.10	In-Situ Chemical Oxidation (ISCO) .....	34
6.11	Monitored Natural Attenuation (MNA).....	34
6.12	Enhanced Anaerobic Bioremediation .....	35
6.13	Remediation Assessment Summary.....	35
<b>7.0</b>	<b>CORRECTIVE ACTION IMPLEMENTATION AND SCHEDULE.....</b>	<b>36</b>
7.1	Feasibility Testing.....	36
7.2	Interim Monitoring Plan .....	40
7.3	LNAPL Baildown Tests.....	40
7.4	EFR Remediation Events.....	41
7.5	Implementation Schedule.....	42
<b>8.0</b>	<b>CONCLUSIONS AND RECOMMENDATIONS.....</b>	<b>42</b>



## LIST OF FIGURES

---

Figure 1	Site Location Map
Figure 2	Facility Site Layout Map
Figure 3	Study Area Map
Figure 4	Soil TPH-DRO Concentration Map
Figure 5	GW TPH-DRO Concentration Map - Shallow Zone
Figure 6	GW TPH-DRO Concentration Map - Deep Zone
Figure 7	Site Plan and Sections
Figure 8	GW Elevation Contour Map – Shallow Zone
Figure 9	GW Elevation Contour Map – Deep Zone

## LIST OF TABLES

---

Table 1	Historical Monitoring Well Gauging Data Summary
Table 2	Well Construction Details Summary
Table 3	Historic Soil Analytical Data Summary
Table 4	Well Development Summary
Table 5	Historic Groundwater Analytical Data Summary
Table 6	Pump Test Recovery Well Data Summary
Table 7	Pump Test Well Gauging Data Summary

## LIST OF APPENDICES

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Appendix A	As-built Drawings and Historical Photograph
Appendix B	Tidal Influences on Groundwater Elevation and Movement
Appendix C	Soil Boring Logs
Appendix D	Laboratory Data – Soil Summary
Appendix E	Soil Disposal Manifests
Appendix F	Laboratory Data – Groundwater Summary
Appendix G	Transducer Data Graphs
Appendix H	Seep Investigation Photo Log
Appendix I	Laboratory Data – Seeps Summary

## **1.0 INTRODUCTION**

### **1.1 Background**

Geosyntec Consultants (Geosyntec) and Groundwater & Environmental Services, Inc. (GES) have been engaged by NRG Potomac River LLC (the client) to address the presence of petroleum hydrocarbons in the soil and groundwater in the vicinity of the Potomac River adjacent to the Potomac River Generating Station (PRGS) site. A Site Location Map is included as **Figure 1** and a Facility Site Layout Map is included as **Figure 2**. The development of the Corrective Action Plan (CAP) for the PRGS has progressed under direction of the Virginia Department of Environmental Quality (VDEQ) within the regulatory framework outlined in the VDEQ Storage Tank Program Technical Manual (STPT) and associated STPT Appendix document. This CAP contains a summary of recent site investigative work at the PRGS, including monitoring well installation activities, groundwater sampling and gauging activities, pumping study activities, a tidal influence evaluation, and a retaining wall integrity assessment. Various remediation technologies are being evaluated, and a multistep approach to corrective action is suggested, including additional monitoring and investigative effort toward the selection of an effective remedial approach. Additional monitoring data, evaluation and the selected remedial approach will be presented in a future CAP Addendum (CAPA) and an updated Site Conceptual Model (SCM) for the project.

Pollution Complaint (PC) #2013-3154, generated by the VDEQ, was opened following the detection of petroleum hydrocarbons during the closure activities associated with two 25,000-gallon fuel oil underground storage tanks (USTs). In response, VDEQ requested that a Site Characterization Report (SCR) be prepared to describe and characterize the type and extent of the contamination stemming from the two USTs. This report was submitted to the VDEQ on June 11, 2013, in the form of a SCM by URS Corporation (URS). The SCM included a discussion of the initial detection of petroleum hydrocarbons during the closure activities associated with the two fuel oil USTs, as well as descriptions of the various subsurface utilities in the vicinity of the USTs.

The VDEQ subsequently requested the submittal of a Site Characterization Report Addendum (SCRA) as stated in a directive letter dated July 10, 2013. This SCRA was submitted on February 14, 2014 by URS and described the activities associated with a subsurface characterization of the Site using laser-induced fluorescence (LIF), as well as the advancement of soil borings for soil sampling at the site, and the installation of fourteen monitoring wells. The site history, recent field activities, laboratory analytical results, a preliminary risk assessment, and an assessment of remedial options were also discussed in the SCRA.

After review of the SCRA, on March 4, 2014, the VDEQ requested that a CAP be developed for the referenced site and requested the CAP be submitted by September 5, 2014. The objective of this CAP is to summarize the site characterization data and evaluation, present an updated SCM based on this data, and to provide a presentation, assessment, and evaluation of the viable remedial technologies that can be employed, consistent with the CAP requirements. This CAP also presents preliminary data and



evaluation related to additional site characterization that was completed in certain portions of the Site in response to directives within the March 4, 2014 VDEQ correspondence.

## **2.0 SITE DESCRIPTION / FACILITY BACKGROUND**

Braddock Light and Power first began developing the site as a power generating facility in the 1940s. The first generating unit was constructed by 1949 and the last of the five units was brought online in 1954. Shortly after initial construction in the late 1940s, the facility was acquired by the Potomac Electric Power Company (now known as PEPCO). The generating facility was operated for most of its history by PEPCO, ranging from the late 1940s until December 2000 when it was acquired from PEPCO, along with other regional generation assets by Southern Energy, Inc., a unit of the Southern Company. In 2001, Southern Energy, Inc. was spun off from Southern Company and became Mirant Corporation (Mirant), which then merged with RRI Energy, Inc. in 2010 to become GenOn Energy, Inc. (GenOn). In July 2012, NRG Energy, Inc. acquired GenOn. On October 1, 2012 the coal power plant was decommissioned and ceased operation. A Facility Layout Map, presented as **Figure 2**, shows the entire area of the former coal power plant.

The facility used Number 2 (No. 2) fuel oil to preheat its generating unit boilers and coal as its primary fuel to generate electricity. The No. 2 fuel oil was stored in two adjoined 25,000-gallon USTs centrally located within the power plant complex (see **Figure 2**). Other accessory USTs were formerly present onsite as noted in the following section, including several kerosene USTs. These accessory USTs were previously closed and properly addressed under the VDEQ program.

As noted above, the current investigation and this CAP focus on two primary 25,000 gallon No. 2 fuel oil USTs which were decommissioned in 2012. Background on the regulatory compliance history of the two 25,000 gallon fuel oil USTs is presented in the following sections.

### **2.1 Physical Setting**

The PRGS is located at 1400 North Royal Street in Alexandria, Virginia and adjacent to the Potomac River. The PRGS is positioned approximately 108 river miles north of the mouth of the Potomac River confluence of the Chesapeake Bay. The area surrounding the PRGS facility is mixed commercial and residential use. A Site Location Map denoting the topographic and geographic features surrounding the PRGS facility is attached as **Figure 1**. The Mt. Vernon Trail, a National Park Service (NPS) multi-use, recreational path, borders the eastern facility property boundary along the Potomac River waterfront. The PRGS is situated on a bank or bluff that transitions in elevation from approximately 32 feet mean sea level (ft msl) at the power plant building complex to approximately 10 ft msl at the base of the facility along the Mt. Vernon Trail boundary. The PRGS property, at the top of the bluff, is relatively flat with a gentle slope to the northeast.



## **2.2 Facility Description**

### **2.2.1 Facility Description**

The PRGS facility consists of the main plant building, a pump house, a screen house, coal management area, an electrical substation (not owned by the client), railroad loading/unloading area, and several out buildings associated with the operation of the facility. For the purposes of this document, the main plant building can be considered as two separate areas. The power plant building is an enclosed, multi-story structure with a basement. East and adjacent to the enclosed power plant building, is a long, covered utility corridor (formerly known as the “precipitator area”) that is open to the elements. The entire facility encompasses approximately 23 acres. The study area addressed in this CAP includes the boiler room area of the power plant basement, the utility corridor containing the former 25,000 gallon fuel oil USTs, the screen and pump house areas, and the sheet pile bulkhead structure at the base of the facility along the Potomac River. This study area, in total, encompasses approximately 3.3 acres. The following section is a description of each of these study area features as shown on **Figure 2**. A detailed description of the construction of the Main Plant Building, Screen House, and Bulkhead are provided below.

### **2.2.2 Utility Corridor and Boiler Room Area of the Power Plant Building**

The main floor of the utility corridor containing the two 25,000 gallon capacity No. 2 fuel oil USTs is located approximately 34 ft msl. The bottom of the USTs are approximately 18 ft msl. This area of the plant is configured as a long corridor open to the elements with numerous stair wells and overhead catwalks, which access electrical, chemical, ducting and steam lines associated with the operation of the plant. Located due west, and inside the power plant building lies the basement floor of the boiler room area with a base elevation of approximately 20 ft msl. During the operation of the plant, No. 2 fuel oil was pumped from the USTs to the boilers located inside the plant building and used to preheat the boilers. In addition, five circulating water intake pipes enter the boiler room on the east side of the building (beneath the utility corridor) at approximately 25 ft msl. Two of the five intake lines run immediately north and south of the USTs, slightly above the top of the USTs. The intake pipes are each 48-inches in diameter and run from the east side of the main plant building to the screen house.

### **2.2.3 Pump and Screen House Structures**

The screen house is the structure that intakes and screens water from the adjacent Potomac River for use in the power plant. The pump house is situated over and offset to the west of the screen house which contained the pumps that lifted water from the level of the Potomac River to the power plant.

The base of the screen house extends, in depth, to the channel bottom at approximately -18.5 ft msl. Within the screen house structure, there are five clear wells; the clear wells extend approximately 30 feet from the base of the structure (at the channel bottom) to the base of the overlying pump house. The clear wells allowed river water to enter the screen house through a sheet-pile lined channel. The channel was excavated to approximately -18.5 ft msl and extends approximately 1,000 feet into the Potomac River. Water is pumped from the clear wells into five 48-inch diameter intake pipes. These pipes transported



water from the screen house to the boilers in the power plant building. The intake pipes exit the screen house approximately between 14 and 16 ft msl and enter the power plant at approximately 25 ft msl. The ceiling of the screen house rises to the same elevation as an extensional structure (elevation 13.5 ft msl) that is cantilevered from the screen house building over the river and serves as a pedestrian walkway (Mt. Vernon Trail). In addition, a tunnel connects the screen house to the basement of the main plant building, exits the southwest corner of the screen house and enters the southeast corner of the power plant basement.

The roof of overlying pump house building occurs at the same elevation as the main floor of the utility corridor at, approximately 34 ft msl. The pump house roof is essentially an exterior deck extension of the main floor of the utility corridor.

#### 2.2.4 Bulkhead

A sheet-pile bulkhead creates a portion of the east boundary of the Site. A portion of the bulkhead has been integrated into the east wall of the screen house. The bulkhead is approximately 325 feet long and runs approximately north-south along the Site and river. The top of the bulkhead is approximately 10 feet above the river surface or 10 ft msl. The bulkhead is constructed of interlocking iron sheet-piles, driven into the ground. The sheet-piles are approximately 60 feet in length at the center of the bulkhead and taper to 48 feet in length on the ends of the wall. Upon review of historic site plans, it is noted that the base of the sheet-pile bulkheads extend to -50 feet below grade surface (ft bgs). There are several penetrations in the bulkhead consisting of outfalls servicing the power plant. In certain locations, the bulkhead has rusted creating gaps (referred to below as potential seeps).

#### Outfalls

There are a total of seven outfalls that were used by the plant. Five of the seven outfalls (Outfall 003, 007, 008, 009 and 010) run adjacent to the fuel oil USTs or run through the utilities adjacent to the USTs. Four outfalls (Outfall 003, 008, 009 and 010) penetrate the river bulkhead and discharge to the river north of the screen house. Two outfalls, (Outfall 009 and 010) run approximately 12 feet north of the USTs and approximately 5 feet below the bottom of the USTs. Two additional outfalls also discharge to the river north of the screen house, however the location of the piping for these outfalls are further away from the USTs and the outfall locations are north of the bulkhead and penetrate a gabion basket wall. Outfall 005 discharges to the river south of the screen house through an open concrete trench. Outfalls 003, 009, and 010 were permanently closed to meet District Department of the Environment (DDOE) requirements.

The locations of the outfalls are shown in **Figure 2**. Below is a brief description of each of these outfalls.

- Outfall 003 previously carried wastewater from two of the facility's cooling units and floor drains to the Potomac River. In December 2008, a bolted blind flange was installed in the pipe just west of the bike path that eliminated discharge to the Potomac River. Upstream of the flange (towards the facility), the Outfall 003 pipe contains wastewater under pressure. Downstream of the flange, the pipe is plugged with grout where it daylights at the Potomac River.



- Outfall 004 previously carried wastewater from the facility's unit 5 bearing cooling area, unit 5 floor drains, and ramp storm runoff. In October 2008, a bolted blind flange was installed in the pipe just west of the bike path that eliminated discharge to the Potomac River. Upstream of the flange (towards the facility), the Outfall 004 pipe contains wastewater under pressure. Downstream of the flange (towards the Potomac River), the pipe is open to the atmosphere on both ends.
- Outfall 005 previously carried wastewater from backwashing and the roof and floor drains in the screen house, as well as from a drain within the facility. In the area closest to the Potomac River, Outfall 005 consists of a 16" concrete trench, the top of which is level with the ground surface. The trench is approximately four feet deep. Observations made during visits to the Site show that the pipes entering the Outfall 005 trench have been capped.
- Outfall 007 is located approximately 110 north of the screen house and 20 feet north of Outfall 008. Outfall 007 is a storm water outfall and is monitored under National Pollutant Discharge Elimination System (NPDES) Permit Nos. DC0022004 and DCR05A035.
- Outfall 008 is an emergency overflow for a sump that collects stormwater from roofing and paved areas on the east side of the power plant. The pipe is open to the atmosphere on the upstream end, and the discharge end of the pipe is underwater except at times when the tide is exceptionally low.
- Outfall 009 passes the two fuel oil USTs and leads into a FRP manhole located just inside the facility perimeter fence. The pipe is severed inside the facility and plugged with concrete, and is also severed within the manhole. This manhole collects any liquids that migrate from the upstream portion of the Outfall 009 pipe. The downstream portion of the pipe is plugged at the Potomac River.
- Outfall 010 is located near Outfall 009. As identified in the client's submittal of the Work Plan for Outfall Decommissioning to the DDOE in February 2013, the upstream portion of the Outfall 010 pipe was removed from the ground in the mid-1970's during emissions control construction activities. The downstream portion of the pipe runs from the manhole described in the Outfall 009 discussion to the bank of the Potomac River. The pipe is plugged at the Potomac River to prevent discharge.

As indicated above, the facility has initiated measures to close off and seal the piping pathways to the outfalls and therefore conveyances to the river no longer exist in this area (URS SCRA).

### **2.3 Regional Geologic Setting**

The PRGS is located within the middle-Pleistocene age Shirley Formation and is part of the Atlantic Coastal Plain province. The Shirley Formation is characterized by gray and brown sand, gravel, silt, clay, and peat. According to the United States Geologic Survey (USGS) description, the Shirley Formation was formed as river (fluvial) deposits, baymouth barrier and bay-floor plains sediments.



In general, the Coastal Plain consists of an eastward-thickening wedge of unconsolidated gravels, sands, silts, and clays that have been deposited upon an eroded crystalline Piedmont basement rock surface that slopes downward toward the east. Many different depositional environments existed during the formation of the Coastal Plain including marine transgressions and regressions, periods of erosion and deposition, fluvial processes, and structural deformations. As a result of these processes, the presence, thickness, and lateral continuity of geologic units are highly variable.

## **2.4 Fuel Oil UST Testing, Inspection and Repair Summary**

The following is a summary of the UST Record Review completed by URS and provided to GES/Geosyntec for inclusion in this CAP:

- On March 11, 1996, ENSA performed pressure tests on the two 25,000 gallon fuel oil USTs and their associated piping. Both USTs passed the test.
- On October 10, 1996, TR Consulting, Inc. submitted a report to PRGS of the results of an inspection of the western fuel oil UST. The inspection was performed by an inspector certified by the National Leak Prevention Association. The observations in the report included five holes in the tank, as well as one deep pit. Two of the holes, measuring 5/8 and 1/4 inch in diameter, respectively, were located in the north endcap of the UST. One of the holes, measuring 5/8 inch in diameter, was located on the northern side along the west wall of the UST near the north endcap. Two additional small holes, which were tightly lodged with rust and sediment, were also identified in the inspection. The inspector also identified a deep pit in the wall of the UST which he attributed to bacterial activity. He also noted general internal pitting at the 4 o'clock and 8 o'clock regions of the UST, running the length of the UST, and that the corrosion activity seemed to be concentrated at the north end of the tank. The inspector advised that the facility ascertain whether any sources of stray current exist or to look into the cathodic protection in the UST systems. He deemed the UST an acceptable candidate for repair.
- On July 24, 1997, a certified National Leak Prevention Association (NLPA) inspector from TR Consulting, Inc. performed an inspection of the western fuel oil UST. The purpose of the inspection was to ensure that the metal surface inside the tank had been adequately prepared for the application of fiberglass reinforced polymer (FRP). The surface, which had been prepared by sandblasting, needed to have an anchor profile of at least 3.0 millimeters (mm). The inspector measured a minimum anchor profile of 5.5 mm and a maximum anchor profile in excess of 7.0 mm and concluded that the metal surface met the requirements for resin adhesion. The inspector later observed the application of the lining material.
- On August 3, 1997, a certified NLPA inspector from TR Consulting, Inc. performed an inspection of the lining material applied to the western fuel oil UST in July 1997. The inspection included thickness testing, hardness measurements, and electrical continuity. The inspector concluded that the UST had been appropriately lined.



- On December 3, 1997, personnel from Petro Tech, Inc. performed precision tests on the two fuel oil USTs. The USTs and their associated piping, product lines, and leak detectors all met test criteria.
- On December 15, 1998, personnel from L.A. Fritter & Son, Inc. performed precision tests on the two fuel oil USTs. Both USTs passed the tests. No leaks, blockage, or decay were detected.
- On March 10, 2000, personnel from TPH Industries, Inc. entered the containment area of the two fuel oil USTs and pumped out the water covering the area. They pressure washed the entire pit and confirmed that the floor of the containment area was concrete. In one portion of the containment area, several inches of sediment buildup were encountered which may have prompted a previous suspicion that the containment area had a partial dirt floor. After the pressure washing, a visual inspection of the containment area was performed. The inspection revealed no open areas within the pit requiring sealing.
- On August 29 and 30, 2007, Applied Technical Services, Inc. (ATS) performed an inspection of the FRP lining in the eastern fuel oil UST. The inspection revealed that the FRP lining system had failed in the UST. ATS's observations included widespread cracking and numerous large blisters in over 20% of the UST's internal surface. The majority of these failures were along the UST bottom, as well as on both of the heads. Several areas of the blistered lining were observed to be weeping oil. At least one of the blisters was open to the UST's steel surface, and product had begun to seep behind the FRP lining. An ultrasonic thickness (UT) inspection of the UST found no signs of widespread corrosion within the UST, with a minimum thickness of 0.325 inches measured in the nominal 0.385 inch shell. In its preliminary report on the inspection, ATS expressed the opinion that the east UST was "not fit for continued service" to the failed FRP lining, and recommended significant repair or replacement.
- From September 12 to 16 (east UST) and September 20 to 23 (west UST), 2007, personnel from the S.R. Sharp Company performed several repairs on the two fuel oil USTs. Failed areas of the FRP lining inside the UST were removed by chipping and/or abrading. After the removal of the failed lining, an inspection of the substrate steel under the exposed areas was performed. The steel substrate was layered with resin rich Armor Flex woven strand mat, which was top coated with Hiflex to meet the depth of the existing non-failed FRP. This new FRP laminate was blended with the existing non-failed FRP laminate. After abrasive blasting the UST interior (to assist with lining adhesion and bonding), personnel spray coated the entire interior with a UL listed GS-900 lining system. Seams in the liner were troweled as necessary using GC-900 trowel material.
- On September 1, 2009, personnel from APEX Companies, LLC, performed pressure tests on the two fuel oil USTs. Both tanks passed the tests.
- On December 16, 2010, personnel from Triumvirate Environmental, Inc. performed cleaning and inspection of the eastern fuel oil UST. Approximately 2,100 gallons of No. 2 fuel oil were evacuated from the UST during the cleaning using a vacuum truck, after which the UST was cleaned manually using a rubber squeegee and pressure washer. Following cleaning, the FRP liner was visually inspected and photographed. No defects in the liner were observed.



during the visual inspection. A 3-inch steel equalization line that connected the two fuel oil USTs was cleaned and sealed with hydraulic cement from the eastern end, after which the eastern end of the pipe was capped with a 3-inch expandable plug.

- On December 23, 2010, personnel from Triumvirate Environmental, Inc. performed cleaning and inspection of the western fuel oil UST. Approximately 1,100 gallons of No. 2 fuel oil were evacuated from the UST during the cleaning using a vacuum truck, after which the UST was cleaned manually using a rubber squeegee and pressure washer. Following cleaning, the FRP liner was visually inspected and photographed. Several minor defects in the liner were observed during the visual inspection. These defects consisted of small areas approximately ¼ to 1 inch in diameter where pitting in the liner had exposed the interior wall of the tank. A 3-inch steel equalization line that connected the two fuel oil USTs was cleaned and sealed with hydraulic cement from the western end, after which the western end of the pipe was capped with a 3-inch expandable plug. (URS 25,000 gallon UST Inspection & Repair Summary)

### **3.0 SUMMARY OF PREVIOUS INVESTIGATIONS**

The site was characterized in 2013 by URS using soil borings, LIF techniques, and groundwater monitoring wells to characterize subsurface conditions and to evaluate the extent of petroleum-related constituents in soil and shallow groundwater. Beneath the areas of the USTs, the groundwater table is approximately 24 ft bgs and the intervening soils are very heterogeneous. Fill material was encountered up to a depth of 20 ft bgs, underlain by interbedded silty clay and clayey sand of the Shirley Formation with occasional lenses of sand gravel and gravel. The clay content decreased between 20-30 ft bgs and the sediments are more coarse-grained and typical of the sand and gravel of the Potomac Group below 30 feet.

Based on the findings, URS concluded that petroleum constituents are present in site soils to depths at least 32 ft bgs and extending to approximately 120 feet northeast from the tanks. However, soil borings in the building basement adjacent to the USTs did not detect Diesel Range Organics (DRO) at concentrations greater than the regulatory reference value listed in Table 5-11 of the VDEQ Storage Tank Program Technical Manual for fuel-saturated soils.

Light non-aqueous phase liquid (LNAPL) was detected in two wells, one of which is near the USTs (at a depth of 30 ft bgs). Groundwater monitoring results indicate that petroleum-related constituents (i.e.: Gasoline Range Organics [GRO], DRO, Benzene, Toluene, Ethylbenzene, Xylene [BTEX], Naphthalene and Methyl-tert-butyl ether) were detected at concentrations higher than risk-based screening levels. Total BTEX concentrations as high as 188 micrograms per liter (µg/L), Naphthalene up to 263 µg/L, and Total Petroleum Hydrocarbons (TPH)-DRO up to 170,000 µg/L were detected.



#### **4.0 ADDITIONAL SITE ASSESSMENT AND INTERIM ACTIONS FOR CAP DEVELOPMENT**

##### **4.1 Introduction**

In the March 4, 2014 directive correspondence, VDEQ requested numerous additional investigation tasks and that the facility initiate interim remedial measures at the Site. The following sections present a summary of the activities completed by the Geosyntec and GES consulting team from May through August 2014 in response to the VDEQ directives.

##### **4.2 Bulkhead/Pump House Assessment**

As described in Section 2.2, the screen house is the structure that takes in and screens water from the Potomac River for use in the power plant. The pump house is situated over and offset to the west of the screen house and lifted water from the level of the Potomac River to the power plant. **Figure 2** presents a summary of as-built conditions of the screen house, pump house, and associated retaining wall. The retaining wall, constructed from corrugated steel sheet piling, extends along the bank of the Potomac River and provides structural support for the screen house and water intake structures. Based on as-built drawings and a historical photograph (both included in **Appendix A**), taken at the time of construction, this sheet piling surrounds the screen house but does not extend up to the elevation of the pump house. The floor of the pump house extends over top of the wall of the bulkhead behind the screen house. All sheet piling was installed to a depth of -50 ft msl and extends to elevations specified in the design drawings. A channel for intake water was dredged to a depth of -18.5 ft msl extending into the main channel of the Potomac River.

West of the screen house, the bulkhead extends from 10 to 13 ft msl to -50 ft msl. The bulkhead appears to be continuous behind the screen house; however since the screen house and pump house units 1 and 2 were constructed at different times from units 3-5, the bulkhead was extended at least once from the original installation. The foundation and intake structures of the screen house and pump house are both constructed of poured concrete. All of the sheet piling behind and along the side of the screen house are currently buried. The groundwater elevation immediately west of the screen house is approximately 8-10 ft msl, indicating there is approximately 2 feet of bulkhead above the groundwater table in the vicinity of the screen house.

Construction plans, indicate that the sheet piling is installed to -50 ft msl along the entire bulkhead along the Potomac River, but the top elevation varies slightly. The top of the bulkhead is visible from the NPS recreation trail along the alignment of the retaining wall, except for the portion where the trail is cantilevered from the screen house over the water. The screen house is open to take in water from approximately -2 ft msl to a depth of -18.5 ft msl, matching the bottom of the dredged channel. Design drawings indicate the bulkhead extends from 18.5 ft msl to -50 ft msl and that the floor of the screen house (at -18.5 ft msl) is installed over the top edge of the bulkhead along the alignment of the water intake openings to the screen house. Rip-rap was used as backfill against the bulkhead north of the screen house units 3-5 as indicated on the design drawings (see **Appendix A, drawing 8757-FC-85**) and a metal mesh material was used to hold the backfill in place. This riprap backfill was inspected during site



inspections of the northern section of the retaining wall. Rip-rap is likely present behind the remainder of the bulkhead but covered with topsoil and grass along portions of the NPS recreation trail. The rip-rap was not inspected during the installation of the monitoring wells directly behind the bulkhead (i.e. TW-3 through TW-7).

### **4.3 Ongoing Liquid Level Monitoring**

Beginning on March 7, 2014, weekly groundwater and LNAPL gauging has been conducted for groundwater wells at the PRGS in response to the VDEQ directive letter dated March 4, 2014. Weekly groundwater gauging and LNAPL recovery efforts continue to date. Depth to groundwater (DTW) and Depth to Product (DTP) are measured to the nearest one-hundredth of a foot (0.01 ft) with an electronic interface probe (EIP) in each monitoring well to a marked reference point (datum) at the top of the inner well casing.

Detections of LNAPL, since the start of weekly gauging in March 2014, have occurred at the following wells:

- TW-09S/MW-8S - ranging from 0.01 ft to 1.07 ft thick, occurring 13 of 19 events
- TW-11/MW-31 - ranging from a detected sheen to 0.02 ft thick, occurring 7 of 19 events
- MW-05 – ranging from 0.08 ft to 0.28 ft thick, occurring 2 of 5 events (over 17 days)
- MW-25 - ranging from 0.06 ft to 0.37 ft thick, occurring 4 of 5 events (over 17 days)
- MW-51 – recorded as a sheen, occurring 2 of 6 events (over one month)

Attempts to recover all detectable LNAPL, have occurred during gauging events conducted since the inception of the monitoring program at the site beginning in December 2013. To date, less than one gallon of LNAPL has been collected at the PRGS from the monitoring wells.

Groundwater gauging data is summarized in **Table 1**. Weekly fluid level monitoring and LNAPL recovery, as outlined in the Work Plans submitted for PRGS on June 19 and July 11, 2014, will continue until otherwise directed by the VDEQ.

### **4.4 Tidal Influences**

Many monitoring wells at the facility exhibit some degree of tidal influence. URS conducted two periods of tidal monitoring at the PRGS occurring from April 22, 2014 through May 12, 2014 and a second period from May 12, 2014 through June 5, 2014. URS utilized water level transducers which logged at 15 minute intervals during the two study events. Data from the initial tidal study period performed at the PRGS was provided to the VDEQ via email correspondence on May 5, 2014 (**Appendix B**).

In summary, URS made the following observations in the May 5, 2014 correspondence:

- Tidal fluctuations in the Potomac River influence groundwater elevation on a daily scale, but groundwater elevation is more strongly influenced by precipitation events and infiltration;



- The range of 0.1 to 0.7 feet per cycle (feet/cycle) observed among the study wells is less than the predicted tidal fluctuation of the Potomac (approximately 3 feet/cycle);
- Wells TW-02 and TW-14 did not exhibit strong cyclic variability that is characteristic of the other five study wells. Well TW-02 was the farthest well from shore (40 feet), representing a section of the water table that may be less affected by tidal influence; and
- TW-14 appears to be isolated from tidal influence but is strongly influenced by precipitation and infiltration.

Evidence of tidal influence has also been observed by GES during the August 2014 pumping study. Further discussion of tidal observations made during the August 2014 pumping study can be found in Section 4.7.

#### **4.5 Additional Soil Delineation**

On June 19, 2014, GES, in collaboration with Geosyntec, submitted the *Interim Activities – CAP Development Work Plan (Work Plan) - Part I* to the VDEQ. The Work Plan was submitted in response to VDEQ directive letter dated March 4, 2014 (Directive Letter). This Work Plan proposed additional soil boring and well installations at the PRGS.

The Work Plan also proposed the modification of the existing “TW” (temporary well) series wells from 1-inch diameter to 2-inch (or 4-inch) to better facilitate representative groundwater sampling and product recovery. The Work Plan divided the well installations into zones within the study area which were selected based on local characteristics and factors inherent to the particular area:

- Zone 1 – area immediate to UST source zone;
- Zone 2 – area located in basement of power plant building;
- Zone 3N- area immediately north of USTs;
- Zone 3S- area immediately south of USTs;
- Zone 4 – area located on upper deck, outside and downgradient of the USTs;
- Zone 4N – area north east of USTs, outside and located on a steep embankment , grading downward toward the NPS Mt. Vernon Trail area;
- Zone 4S – area south east of USTs, outside on the upper deck located near tank and chemical storage infrastructure – no wells were placed in this area;
- Zone 5 – screen house building – no wells were placed in this area;
- Zone 5N – area located along the north lower elevation at the base of the facility, adjacent to the NPS Mt. Vernon Trail and the Potomac River waterfront that contains former Outfall 003, 004, 007, 008, 009 and 010 locations; and
- Zone 5S - area located along the south lower elevation at the base of the facility, adjacent to the NPS Mt. Vernon Trail and the Potomac River waterfront that contains former Outfall 005 location.

Evidence of a confining to semi-confining clay layer was consistently observed at approximately 25 ft bgs in both the LIF (completed by URS) and soil boring profiles. It is suspected that this lithologic feature may be restricting vertical migration of LNAPL near the USTs. Therefore, GES was directed by VDEQ not to “straddle” or breach this confining feature (when observed) with new well screen construction but to install co-located shallow and deep wells that are screened above and below the feature.

Soil boring and monitoring well locations for the most recent investigation were placed at the locations of former LIF, soil boring, or temporary well (TW) points in order to target specific vertical intervals identified during previous investigations. In addition, the utilization of former soil boring, LIF, and TW penetrations provided a safeguard against contacting the numerous subsurface utilities and buried power plant infrastructure components existing beneath the study area.

Beginning on July 23, 2014 and ending August 22, 2014, a total of 39 soil borings and monitoring well conversions were advanced and installed within the PRGS study area by Odyssey Environmental Services, Inc. (Odyssey) and Kodiak Field Services (Kodiak), under the direct supervision of GES field staff. Each monitoring well was constructed with either a 2-inch or 4-inch diameter polyvinyl chloride (PVC) 0.020-slot screened casing, a 2-inch or 4-inch diameter PVC solid riser casing, and a flush-mounted bolting well cover. The locations of the monitoring wells are illustrated on **Figure 2**. The well construction details for the revised PRGS well monitoring network are summarized in **Table 2**. A compilation of boring logs containing lithologic, volatile organic compound (VOC) screening levels using a photoionization detector (PID) and well completion information is provided as **Appendix C**.

Please note that the naming conventions established by URS for the “TW” series (TW-1 through TW-14) wells (where TW refers to temporary well) has been modified for those wells that have been re-drilled. During the 2013 site investigations at PRGS, URS attempted 80 exterior soil borings, referred to as B-1 to B-80, and two interior borings located in the power plant basement referred to as SB-1 and SB-2. A total of 46 exterior borings were characterized via LIF probe technology. Five of these exterior borings and both of the interior borings were installed or duplicated for lithologic and VOC characterization via direct push technology. Fourteen of the original “B” (“boring”) series borings were converted to 1-inch temporary wells (“TW”) by URS but the TW wells were designated in a presumed chronological order and did not relate (in number) to their corresponding boring (or “B”) designation. A summary of URS’s site investigations with maps denoting the boring and well installation designations is presented in previously submitted SCM and SCRA, and referenced in Section 3.

Because all of the original boring locations placed by URS were re-penetrated and/or modified by GES in the latest subsurface investigation, GES has reverted to using the boring number designation assigned to the original location. For example, original LIF boring B-05, which was initially converted to 1-inch well TW-01, is now a 4-inch well MW-05.

Of the 39 soil borings installed by GES, six penetrated existing TW locations. These new wells were installed to the terminal depths of the corresponding prior penetrations and are considered “deep” wells within the revised PRGS monitoring well network. A series of “shallow” wells was installed during the

August 2014 field investigation per VDEQ requirements. Many of the shallow wells, designated with an “S” (ex. MW-09S) serve as companion or co-located wells to the re-drilled “deep” wells (ex. MW-09).

Prior to the advancement of the soil borings, a public utility markout was conducted (e.g. Miss Utility was notified and completed a markout of services at public areas). Following the utility markout, Odyssey “pre- cleared” each boring to a depth of 6 feet, using air-knife excavation techniques. Air knife excavation safely removes material in boreholes without interfering with subsurface utilities.

Continuous vertical soil profiles were collected using 5-foot length acetate sleeves pushed by a Geoprobe 7822DT direct-push drilling rig. This drill rig was also equipped with hollow stem auger (HSA) capabilities to facilitate the over- drilling and installation of 2-inch and 4-inch diameter monitoring wells. The soil boring profiles were collected to terminal depths ranging from 13 to 38.5 ft bgs, depending on the location of the boring and/or the completion depth of the previous, corresponding penetration. For borings collected in Zones 4N (MW-106, 107, and 108) and Zone 5S (MW-103, 104, and 105), soil profile samples were collected every 1 foot with hand augers to a terminal depth ranging from 10 to 15 ft bgs.

Soil samples were collected and screened with a calibrated PID to determine the presence and degree of VOC impact to the soils. Each length of the collection interval was screened and recorded for VOCs with the PID meter at approximately every 6 inches. Up to two soil samples were collected for analysis from interval depths that exhibited the highest PID readings or were collected just above the water table (in the absence of elevated PID response). PID readings ranged from 0 to 510 parts per million (ppm). The highest PID reading was observed in location MW-14 (Zone 1) at a depth of 29 ft bgs.

Soil samples were placed in laboratory supplied glass jars, packed in ice and couriered to Fairway Laboratories, Inc. (Fairway) in Altoona, Pennsylvania for analysis. Per VDEQ request, the soil samples were analyzed for TPH-DRO in accordance with Environmental Protection Agency (EPA) Method 8015B.

The soil sample results collected from the most recent soil investigation are presented in the Historical Soil Analytical Data Summary as **Table 3**. A Soil Concentration Map for TPH-DRO is attached as **Figure 4**. Complete laboratory analytical results and chain of custody documentation from the soil investigation are attached as **Appendix D**. A summary of soil results collected from the various study area zones (as defined earlier in this report section) are as follows:

Zone	Minimum Detected TPH-DRO in Soil	Maximum Detectable TPH-DRO in Soil
1	114.4 mg/kg MW-10S (19.25' - 19.75')	92,180 mg/kg MW-51 (29.5' - 29.9')
2	308.7 mg/kg MW-110 (21' - 21.5')	13,160 mg/kg MW-110S (12.5' - 13')
3N	Non-detect (<30.18 mg/kg) MW-16S (23')	Non-detect (<30.97 mg/kg) MW-52 (32')
3S	Non-detect (<28.33 mg/kg) MW-100 (24')	Non-detect (<30.08 mg/kg) MW-70 (32')



Zone	Minimum Detected TPH-DRO in Soil	Maximum Detectable TPH-DRO in Soil
4	2,389 mg/kg MW-72S (23'-23.5')	3,286 mg/kg MW-27 (23.5'-24')
4N	92.35 mg/kg MW-107 (9'-10')	692.1 mg/kg MW-106 (9'-10')
5S	53.29 mg/kg MW-103 (7'-8')	782.9 mg/kg MW-104 (5'-6')

#### 4.5.1 Soil Waste

All soil waste generated during well installation activities was containerized in standard roll-off boxes. Two roll-off boxes of soil waste, at 16.5 and 13.0 tons each, were removed on August 20, 2014 and August 27, 2014, respectively. Soil manifests for both soil roll-off boxes are included in **Appendix E**.

### 4.6 **Additional Groundwater Delineation**

#### 4.6.1 Monitoring Well Installation

As previously noted, many new shallow groundwater monitoring wells (designated “S”) and deep wells (no designation) were placed as co-located pairs and screened above and below the observed clay feature noted approximately 25 ft bgs beneath the study area.

In Zone 1, 11 soil borings were converted into 4-inch monitoring wells by Odyssey. Monitoring wells MW-05, MW-08S, and MW-14 replaced the existing monitoring wells TW-01, TW-09S, and TW-13, while new wells MW-01S, MW-10S, MW-11, MW-15S, MW-25S, MW-25, MW-51 and MW-51S were installed at former LIF boring locations. Wells in this zone were completed at depths ranging from 25 to 38.5 feet, based on the clay layer observed at approximately 25 ft bgs in the LIF and soil borings in and around Zone 1.

Odyssey installed nine monitoring wells in the basement of the facility (Zone 2). Monitoring well MW-109 was installed at the original SB-2 location, while MW-109S was installed as a paired shallow well for that location. Monitoring well MW-110 was installed at the original SB-1 location, and the paired well for that location was MW-110S. Monitoring wells MW-111, MW-112S, MW-112, and MW-113 were installed north, south, and west in close proximity of SB-1 and SB-2. Wells in the basement were completed at depths ranging from 13 to 24 ft bgs, considering the grade surface of the basement of the facility is approximately 13 feet lower than the grade for Zone 1. Monitoring wells MW-109S, MW-109, MW-110S, MW-110, MW-112S, and MW-112 were constructed as 4-inch diameter wells, and monitoring wells MW-111, MW-113, and MW-114 were constructed as 2-inch diameter wells.

For Zones 3N and 3S, Kodiak installed six 2-inch monitoring wells: MW-16S, MW-16, MW-52, MW-70, MW-100S and MW-100. In Zone 4, Odyssey converted six 4-inch soil borings into monitoring wells. Monitoring wells MW-27, MW-31, and MW-72S replaced three of the existing monitoring wells. MW-72 was installed as a paired well to MW-72S, and MW-30S was installed as a pair well to MW-31. MW-

33 was installed at a former LIF boring location. Wells in this zone were completed at depths ranging from 24.5 to 37.5 ft bgs, based on the observed clay layer similar to the wells in Zone 1.

On the north slope (Zone 4N), MW-107 and MW-108 were installed on the north and south sides of the former Outfall 009 manhole, and MW-106 was installed further down the hill towards the north wall of the pump house. These monitoring wells will help delineate preferential pathways along the former Outfall 009 drainage lines and assess potential migration of dissolved and/or free phase hydrocarbons. Wells in this zone were completed by hand auguring to depths ranging from 10 to 11 ft bgs.

In the lower area of Zone 5S, south along the river front, three monitoring wells MW-103, MW-104, MW-105 were installed by hand auger. MW-105 was installed along the south wall of the pump house to assess potential migration of dissolved phase hydrocarbons. MW-104 was installed to delineate existing well TW-14. MW-103 was installed on the east side of the concrete Outfall 005 culvert next to TW-14, which is on the west side of the Outfall 005 culvert to assess whether this culvert is acting as a barrier and/or a pathway for dissolved phase migration toward. The depth of this concrete culvert extends approximately 4-6 ft bgs and the depth to groundwater in TW-14 is 1-2 feet. Kodiak installed an additional monitoring well, MW-102, to further delineate dissolved phase hydrocarbons TW-14.

Wells were developed by removal of a minimum of three-calculated well volumes or until the purge stream became clear. No development occurred at MW-15S, MW-25S, MW-106, and MW-107 due to insufficient water. Several other wells including MW-108, MW-109S and MW-01S produced very little water after multiple purge and recharge cycles were conducted. Due to a field error, development volumes for wells MW-51S and 72S were not recorded. A summary table of approximate well development volumes is attached as **Table 4**.

#### 4.6.2 Groundwater Sampling Event

URS conducted the first groundwater sampling at the PRGS on December 16, 2013. This initial event involved fluid-level gauging and the collection of groundwater samples from the temporary wells TW-1 through TW-14. GES performed a second groundwater gauging and collection event from the TW-series wells on July 7, 2014. Results from the July 2014 event were forwarded to the VDEQ on July 11, 2014.

Most recently, GES conducted a comprehensive groundwater monitoring event at the PRGS over a several day period including August 13, 15, 16, 21 and 25, 2014. The dates of collection occurred while wells were being completed and developed for sampling. Liquid levels were gauged and recorded at each well prior to purge and sample activities. In addition, a comprehensive “snap-shot” or synoptic liquid level gauging event was conducted August 25, 2014. During purging, a three-well purge volume was computed with purging performed via conventional hand bailing techniques using a one-gallon PVC bailer.

Upon completion of bailing, the wells were allowed to recharge to within 90% of the initial groundwater level prior to sampling. Sample collection was performed via use of a dedicated and disposable polyethylene bailer and bailer string assembly. Groundwater samples were poured into 1-liter amber

glass bottles and immediately packed on ice in cooler chests. Samples were ultimately transported via courier to Fairway to be analyzed for TPH-DRO via EPA Method 8015B.

#### 4.6.3 Groundwater Analytical Results

During the August 2014 groundwater monitoring well sampling event, detectable TPH-DRO concentrations ranged from 150 µg/L (MW-100S) to 281,000 µg/L (MW-51). These TPH-DRO groundwater concentrations were detected within 30 of the total 47 wells comprising the revised PRGS network. MW-108 and TW-12S were not sampled due to lack of available water, and MW-05 was not sampled due to the presence of LNAPL. The remaining fourteen wells were tested non-detect (ND) for TPH-DRO with reporting limits for the parameter ranging between 152 µg/L to 1,500 µg/L. The higher TPH-DRO reporting limits required for select samples (MW-102, MW-105, and TW-3) are attributed to increased suspended solids content. A discussion of development efforts related to MW-102 and MW-105 is discussed earlier in this section.

The groundwater sample results collected from the most recent groundwater sampling event are presented in the Historical Groundwater Analytical Data Summary as **Table 5**. Complete laboratory analytical results and chain of custody documentation from the August 2014 event are attached as **Appendix F**. Isoconcentration maps for TPH-DRO in groundwater for both the shallow zone and deep zone wells have been prepared and are attached as **Figures 5** and **6**, respectively.

Upon review of the isoconcentration maps, the following observations are noted:

- The distribution of the shallow zone TPH-DRO groundwater plume is semi-radial with lobes extending west, southeast and due east from the 25,000 gallon fuel oil USTs.
- The shallow zone wells with the greatest concentration (>10,000 µg/L) are located adjacent and east of the 25,000 gallon fuel oil USTs. An area of increased TPH-DRO groundwater concentration appears at the MW-16S location (Zone 3N) which is at the furthest northern extent of the shallow zone study area.
- The deep wells with the greatest TPH-DRO groundwater concentration (>100,000 µg/L) are located in two distinct areas:
  - Adjacent and east of the 25,000 gallon fuel oil USTs (near deep zone wells with LNAPL detections (MW-05, MW-51 and MW-25) in Zone 1 and,
  - Around TW-06 and TW-05 (Zone 5N) at the NPS property.
- An area of elevated TPH-DRO groundwater concentrations identified at MW-104 and TW-14 (Zone 5S) appears to be affected by an adjacent trench feature.

As previously noted in Section 4.6, the presence of a potential confining/perching clay unit beginning approximately 25 ft bgs necessitated the installation of eight co-located shallow and deep wells screened above and below the feature. The following table summarizes the August 2014 shallow TPH-DRO concentrations noted at the eight new co-located well pairs (with corresponding deep well values when applicable):



Well	Sample Date	TPH-DRO (µg/L)	Screen Interval
MW-01S	8/15/2014	2,670	17 - 27
MW-08S	8/15/2014	7,540	15 - 25
MW-10S	8/15/2014	36,000	17 - 27
MW-15S	8/15/2014	909	16 - 26
MW-16S	8/16/2014	1,720	15 - 25
MW-16	8/15/2014	ND<300	26 - 36
MW-25S	8/15/2014	49,000	16 - 26
MW-25	8/13/2014	1,280	25 - 35
MW-30S	8/15/2014	7,040	16 - 26
MW-51S	8/15/2014	1,590	15.5 – 25.5
MW-51	8/13/2014	1,650	27 - 37
MW-51	8/16/2014	281,000	27 - 37
MW-72S	8/15/2014	5,980	15 - 25
MW-72	8/16/2014	1,340	25 - 35
MW-100S	8/15/2014	ND<300	14.5 – 24.5
MW-100	8/15/2014	ND<152	27.5 – 37.5
MW-109S	8/21/2014	7,500	3.5 – 13.5
MW-109	8/21/2014	ND<600	14 - 24
MW-110S	8/25/2014	6,630	3 - 13
MW-110	8/25/2014	ND<153	14 - 24
MW-112S	8/15/2014	ND<1,500	3 - 13
MW-112	8/15/2014	ND<1,500	14 - 24

In many of the co-located well pairs, the highest value TPH-DRO concentrations occur in the shallow wells (“S”) or the zone screened above the identified clay feature. These elevated shallow zone concentrations correlate to corresponding LIF borings initially characterized at the (deep well) locations. An exception to this observation occurs at the MW-51 / MW-51S pair. In the corresponding LIF boring for this pair (PRGS-51), elevated LIF response occurs both above and below clay feature. Because MW-



51 was utilized as a pumping well during the Aug 11 to 15, 2014 Pump Test (Section 4.7), several groundwater samples were collected from the well between August 13 and 16. The August 13, 2014 test results from deep well MW-51 mirrors the corresponding shallow well (MW-51S) which is expected based the LIF signature. After the conclusion of the pump test, the TPH-DRO concentration at MW-51 increased several orders of magnitude and is likely related to the mobilization of LNAPL toward the well and/or the occurrence of a severe precipitation event on August 12, 2014.

Additional groundwater monitoring is required to better understand the long-term characteristics of the two water bearing zones because the revised well network is only recently established. Additional interpretation will be provided in the future CAPA and updated SCM.

#### 4.6.4 Measured LNAPL Thicknesses

Prior to the August 2014 soil and groundwater characterization events, LNAPL thickness had historically been measured in three of the 14 original TW-series wells including:

- TW-01 (now MW-05) with a single historic thickness detection of 0.01 ft (1/8/14),
- TW-09S (now MW-08S) with a maximum historical thickness= 1.07 ft and
- TW-11 (now MW-31) with a maximum historical thickness=0.02 ft.

During the August 25, 2014 comprehensive liquid level gauging event, LNAPL was detected in the three of the total 45 wells now comprising the PRGS groundwater monitoring well network:

- MW-05 (formally TW-01) with a measured thickness of 0.28 ft,
- MW-25 with a measured thickness of 0.23 ft and
- MW-51 with an unmeasurable product sheen noted.

Although LNAPL gauging data at the PRGS is limited to measurements collected over the last year during a limited number of events, it appears that detectable thicknesses of LNAPL are isolated to wells immediate to the USTs (Zone 1 and Zone 4). More discussion of LNAPL delineation is presented in Section 5.2. Attempts to recover all detectable LNAPL, have occurred during gauging events conducted since the inception of the monitoring program at the Site beginning in December 2013. To date, less than one gallon of LNAPL has been collected at the PRGS from the monitoring wells.

#### **4.7 Interim Recovery Actions / Pumping Study**

An interim remedial measure / pumping study was completed to support the preparation of this CAP, as discussed in the Interim Activities CAP Development Work Plans and follow-up correspondence with the VDEQ. The primary objectives of the interim remedial measure / pumping study were the following:

- Recover LNAPL and dissolved-phase hydrocarbon (DPH) impacts from the subsurface as an interim remedial measure;

- Evaluate the effectiveness of capturing the existing LNAPL and dissolved phase plume via groundwater extraction or minimally intercepting future migration of impacts emanating from source areas; and
- Determine groundwater flow characteristics within the study area (e.g., transmissivity, hydraulic conductivity, sustained yield, and radius of influence [ROI]) and use such data to evaluate potentially effective groundwater remediation technologies to mitigate the further migration of LNAPL and DPH.

#### 4.7.1 Baseline Preparation and Data Collection Procedures

Pump test activities by GES began on August 8, 2014, when eight in-situ LevelTroll pressure transducers were installed and activated in pumping wells MW-51 and MW-72 and observation wells MW-05, MW-11, MW-25, MW-27, MW-31, and MW-107 to begin collecting background water level measurements. The pressure transducers were vented with a desiccant filter to absorb moisture, and gauging was conducted with an interface probe at the time of installation. Also on August 8, 2014, two 4-inch, low drawdown, top-loading pneumatic pumps (QED Environmental Systems LDD AP-4/TL) were installed in pumping wells MW-51 and MW-72. The transducer for each planned pumping well was secured approximately 3 inches above the top of the pump and activated subsequent to pump deployment. The pumps were suspended with a cable tether with the discharge hose routed through totalizing flowmeters, a sample port, and a gate valve. From the gate valve, the discharge hoses were each routed into the top of a tank for temporary storage of the water. The tank was an 18,000-gallon open-top weir tank. The tank was equipped with a high level float that deactivated the pumps upon a high level condition. Compressed air was provided to the pneumatic pumps from an electric air compressor that was powered by a generator. The compressed air line to each pump was equipped with a pressure regulator and cycle counter.

The cycle counter readings were recorded periodically throughout pumping and were used to determine the flow rate and total flow from each pump. The cycle counters were used because of the accuracy of the cycle counter measurements, the known volume of each pump cycle, and the difficulties of measuring the flow from a pneumatic pump with a totalizer because the flow varies and can approach zero between cycles.

#### 4.7.2 Water Level Monitoring

The eight transducers collected measurements from the pumping and observation wells for the three days prior to the start of pumping, during all pumping activities, and continued for three days following the completion of pumping, operating from Friday, August 8, 2014 to Monday, August 18, 2014. The transducers were set to record the water level measurement every 10 seconds in the pumping wells and every 30 seconds in the observation wells. Hydrographs of all of the transducer water level measurements are shown in **Appendix G**.

Tidal fluctuations were observed at all monitoring wells with transducers except monitoring well MW-107. The magnitude of the tidal fluctuation was determined using measurements prior to the start of



pumping. Tidal fluctuations ranged from approximately 0.08 feet at MW-05 to 0.47 feet at MW-31, with the tidal fluctuation correlating with distance from the river. Estimates of individual tidal fluctuations are shown below:

Well	Tidal Fluctuation
MW-05	0.08 feet
MW-11	0.31 feet
MW-25	0.35 feet
MW-27	0.42 feet
MW-31	0.47 feet
MW-51	0.32 feet
MW-72	0.35 feet
MW-107	0 feet
Average	0.3 feet

Additional manual water level measurements were collected from all existing monitoring wells using an interface probe. Measurements were collected when the transducers were deployed, just prior to the start of pumping, during pumping, after pumping stopped, and when the transducers were stopped. This data is presented in **Table 6**. However, due to the tidal fluctuations and rain event during pumping, determinations of pumping influence could not be made from the manual measurements.

#### 4.7.3 Pumping Operation

On Monday, August 11, 2014, pumping began at monitoring well MW-72 at 10:36 AM, and pumping began at monitoring well MW-51 at 11:26 AM. Pumping stopped from 12:28 PM to 12:51 PM and from 1:18 PM to 1:26 PM on August 11, 2014, due to a problem with the power generator, but was otherwise uninterrupted throughout the test.

At monitoring well MW-51, pumping continued throughout the week, until the conclusion of the test at 5:18 AM on Friday, August 15, 2014, approximately 89 hours. The initial sustained flow rate at the onset of pumping was approximately 1.8 gallons per minute (gpm) and decreased to an average of 1.6 gpm for the entire test. The water level was drawn down to a maximum of 5.3 feet from initial static levels, and the pump intake was approximately six feet below the starting water level. However, for approximately one day following the significant rain event that occurred during the pumping study, drawdown was limited to a maximum of 3.8 feet, which suggested that the maximum flow rate of the pump was not sufficient to draw the water table to near the pump intake.

At monitoring well MW-72, the water level was drawn down to the pump intake (approximately 5.7 feet below the starting water level) within four minutes of pumping at the well. The flow rate of the pump then remained relatively consistent with an average flow rate of 0.4 gpm. On Wednesday, August 13,

2014, after pumping for approximately 46 hours, pumping was stopped at monitoring well MW-72 and recharge was monitored. After approximately two hours and the water level having returned to approximately 98% of the water level prior to pumping, the pump and transducer in monitoring well MW-72 were removed from the well, decontaminated, and installed in monitoring well MW-25. The pump was moved to MW-25 because of the limited recovery and influence observed as a result of pumping at monitoring well MW-72 and because of the presence of LNAPL at monitoring well MW-25, which was measured to be 0.35 feet on August 13, 2014, prior to the pump being deployed.

Pumping at monitoring well MW-25 began at 12:15 PM on August 13, 2014 and continued through the conclusion of the test (approximately 41 hours). The flow rate was approximately 1.7 gpm throughout the test. The water level was drawn down to the pump intake, which was approximately 5.3 feet below the starting water level. LNAPL was recovered from the well, and the LNAPL thickness reduced from a maximum of 0.43 feet to approximately 0.01 feet. However, it was observed that at high tide, the water level was not drawn down to the pump intake and LNAPL recharged in the well. On the second day of pumping at MW-25, the LNAPL thickness was 0.01 feet at 10:06 AM and 0.24 feet three hours later at 1:00 PM. LNAPL accumulation was observed on top of the water in areas of the first weir tank compartment. However, LNAPL did not cover the compartment and the LNAPL thickness was not measurable and therefore a recovered volume cannot be estimated.

A detailed Pump Test Recovery Well Data Summary is presented as **Table 6**. The following table presents an overall summary of the pumping schedules, rates and total withdrawal:

Pumping Well	Start of Test	End of Test	Duration of Test	Maximum Drawdown	Total Withdrawal from Well	Average Pumping Rate
MW-51	08/11/14, 11:26 AM	08/15/14, 5:18 AM	89 hours	5.3 feet	8,751 gallons	1.6 gpm
MW-72	08/11/14, 10:36 AM	08/13/14, 9:25 AM	46 hours	5.9 feet	1,179 gallons	0.4 gpm
MW-25	08/13/14, 12:15 PM	08/15/14, 5:18 AM	41 hours	5.5 feet	4,240 gallons	1.7 gpm

A total of approximately 14,170 gallons of extracted groundwater was generated and stored in the 18,000-gallon open-top weir tank located in the vicinity of pumping well MW-72. The stored groundwater will be characterized and hauled offsite for proper treatment and disposal.

#### 4.7.4 Pumping Well Sample Collection

During the first day of pumping, groundwater samples were collected from a sample port on the pump discharge line of active pumping wells MW-51 and MW-72. During the third day of pumping, groundwater samples were collected from all three pumping wells from the discharge line sample ports while the pumps were in operation. Following completion of the test, additional groundwater samples were collected from the three pumping wells. To prevent disruption of the recharge monitoring, the samples were collected one day following the conclusion of pumping using a sample bailer.



Each sample was analyzed by a certified laboratory for TPH-DRO via EPA Method 8015B. An analytical summary of the pumping well samples is shown below.

Pumping Well	Date	TPH-DRO (µg/L)
MW-51	08/11/14	1,180*
	08/13/14	1,650*
	08/16/14	281,000
MW-72	08/11/14	<300*
	08/13/14	1,100*
	08/16/14	1,340
MW-25	08/13/14	1,280*
	08/16/14	LNAPL (0.06 ft)

\*denotes sample collected during active pumping

Increases in TPH-DRO concentrations were observed following the start of pumping. The increased concentrations were likely caused by a combination of the following two factors:

- The continuation of pumping expands the reach of capture within an associated pumping well's specific hydraulic storage connections; and
- The availability of water volume to dilute static concentrations diminishes with water column depletion.

#### 4.7.5 Pump Test Data Evaluation

A forthcoming CAP Addendum will include a summary of transmissivity, storativity and hydraulic conductivity values determined from the solution(s) providing best fit for each of the observation wells demonstrating influence. The pumping wells and all monitoring wells determined to demonstrate influence during the MW-72D, MW-51D, or MW-25D pumping periods are to be analyzed with Aqtesolv 4.5 software using "best fit" curves derived from either the Theis (1935), the Cooper-Jacob (1946) and/or the Neuman (1976) solutions for both drawdown and recovery. From graphical review, the following wells have been selected for an aquifer solution analysis:

- Pumping wells: MW-25, MW-51, and MW-72; and
- Observation wells: MW-05, MW-11, MW-25, MW-27, MW-31, MW-72, and MW-107.

The Theis (1935), Cooper-Jacob (1946) and/or the Neuman (1976) solutions to be used for both drawdown and recovery are described below:



- The Theis solution was derived to provide a solution for unsteady flow to a fully penetrating well in an unconfined aquifer. Corrections to the Theis solution can be made to accommodate unconfined water systems and the effects of partially penetrating wells. These corrections are implemented in the Aqtesolv 4.5 software. From the Theis solution method, hydraulic parameter estimates of aquifer transmissivity (T) and storativity (S) can be determined. If aquifer thickness is known, then hydraulic conductivity (K) can be determined using the following equation

$$K = T/b,$$

where K is hydraulic conductivity, T is transmissivity, and b is aquifer saturated thickness.

- The Cooper-Jacob method was derived to provide a solution for nonleaky confined aquifers using a straight-line plot of drawdown data against logarithm time from the start of pumping. Values for S and T can be obtained through use of the Cooper-Jacob solution. Corrections to the Cooper-Jacob solution can be made to accommodate the partial dewatering of the water table or unconfined water systems. These corrections are also implemented in the Aqtesolv 4.5 software.
- The Neuman method was derived for an unconfined aquifer system as it addresses dewatering of the water table (reduction of the saturated thickness and delayed yield) by both vertical and horizontal flow components. The Neuman method utilizes a log-log plot of drawdown versus time to determine the transmissivity (T), Storativity (S), Specific Yield (Sy) and hydraulic conductivity anisotropy ratio ( $\beta$ ) of the aquifer.

#### 4.7.6 Observation Well Response

A graphical review of the hydrographs reveals widespread pumping influence but also relatively inconsistent aquifer characteristics among all evaluated pumping well and observation well data sets. Upon review of the hydrographs, the following noteworthy trends are evident:

- Pumping at monitoring well MW-51 decreased water levels at monitoring wells MW-05, MW-11, MW-25, MW-27, and MW-31, which range in distance from MW-51 between 30 and 59 feet. Influence at monitoring well MW-72 was observed after pumping on the well had stopped, but this influence is more likely to be attributed to the pumping at monitoring well MW-25.
- Pumping at monitoring well MW-72 caused a small decrease in water level at monitoring well MW-25 prior to the start of pumping at monitoring well MW-51. Additional influence from MW-72 pumping may have occurred while pumping also occurred at monitoring well MW-51, but this influence cannot be distinguished from the monitoring well MW-51 influence.
- Pumping at monitoring well MW-25 decreased water levels at monitoring wells MW-05, MW-11, MW-25, MW-27, MW-31, and MW-72, which range in distance from MW-25 between 19 and 67 feet.
- Monitoring well MW-5, which exhibited minor influence from pumping at MW-51 and MW-25, had LNAPL detected for the first time immediately following the conclusion of pumping. More



specifically, immediately following the conclusion of pumping on August 15, 2014, the LNAPL thickness was 0.08 feet, and on August 25, 2014, 10 days following pumping, the LNAPL thickness increased to 0.28 feet.

- Monitoring well MW-11 (approximately 19 feet from MW-25 and 30 feet from MW-51) exhibited more than a foot of drawdown during pumping at those two wells.
- On August 12, 2014, a significant rain event occurred during pumping that caused flooding around monitoring wells MW-27, MW-31, MW-51, and MW-107 between 2:09 PM and 2:43 PM. For a brief time at each of these four monitoring wells, water infiltrated the well through the top of the well casing. The effects of this added water are visible in the hydrographs.
- Monitoring well MW-107 exhibited limited connectivity to the aquifer. There was no tidal influence observed and no pumping influence observed. In addition, after a slug of rainwater infiltrated the well on the second day of the test and after a slug of water was removed from the well during the groundwater sampling conducted one day following the test, it was more than one day before the water level returned near the static elevation.

#### 4.8 Bulkhead Integrity Assessment and Seep Sampling

On August 13, 2014, GES, with support from Geosyntec, performed a groundwater seep assessment along the north and south-side metal bulkhead/sheet pile structures flanking the PRGS screen house building. The north and south-side sheet pile structures contain several former outfall structures emanating from the PRGS power plant which have since been capped and/or sealed with concrete slurry. The seep assessment was proposed in the *Work Plan – Part I* submitted to the VDEQ on July 19, 2014. The objective of the seep assessment was a continued evaluation of potentially impacted groundwater through the two metal bulkhead sections as noted and reported by URS in the February 14, 2014 SCRA report.

During the hours approaching low tide for the day (5:43 PM), GES visually inspected the entire bulkhead structure both by land and from the water. To enhance the seep investigation, a Fluke Ti45FT thermal imaging camera was utilized to identify areas of the bulkhead structure that might exhibit “cold spots” where groundwater seepage might be more evident.

Upon investigation, GES identified six potential seepage locations (Seep A through Seep F) along the north and south-side bulkhead structures. GES proceeded to mark these locations with paint and then measure the locations to a common datum located at the top of the bulkhead structure. GES was successful at collecting two seep samples (Seep B and Seep D) from the total six identified potential seep locations but the other four did not produce any measurable moisture. A photographic log presenting the position of the six potential seeps along the bulkhead structures with the individual thermal signatures at each of the identified seeps is presented in **Appendix H**.

In summary, the identification of potential seeps was made primarily by the visual presence of moisture and relic mineral precipitation existing around a perforation or structure found in the bulkhead wall. No “cold spots” other than the reduced temperature signature of a flowing seep (Seep B) were evident with

the thermal imaging camera. A majority of the identified potential seeps including Seeps A, B, C and D exist at or below the high tide mark stains on the bulkhead. These seeps (A through D) exist on the north-side bulkhead wall of the power plant screen house building. Seeps E and F are located on the south-side bulkhead wall and appear slightly higher than the observed high tide staining marks at these locations. It is noted that the August 13 event occurred a day after a major rain event but did not appear to significantly alter the tides.

As noted, aqueous samples were collected from Seeps B and D via the use of a dedicated 60 mL syringe and polyethylene tubing. Samples were transferred to a 50 mL glass vial preserved with hydrochloric acid and an unpreserved 250 mL glass jar. The samples were submitted to EuroFins Lancaster Laboratory for TPH-DRO analysis via EPA Method 8015C and Specific Conductance (SPC) via SM 2510. The analytical results for the two collected seep samples are presented in **Table 5** with the laboratory reports and accompanying COCs included in **Appendix I**. The analytical results are summarized as follows:

Location	TPH-DRO (µg/L)	SPC (µmhos/cm)
Seep B	320	822
Seep D	Non Detect (<42)	769

## 5.0 HYDROGEOLOGY / CONCEPTUAL SITE MODEL

### 5.1 Site Geology

The February 14, 2014 URS SCRA report and the accompanying SCM developed for the PRGS make several observations on lithologic characteristics encountered during the initial soil boring and LIF events performed in December 2014. During the August 2014 soil boring and well installation event, GES collected additional subsurface data to support the evolving SCM for the PRGS. The primary contributing lithologic features identified for the PRGS thus far are as follows:

- The upper 20 feet of soil surrounding the UST cavity is comprised of clayey soil matrix containing rubble material including broken brick, river gravel and concrete fragments. The presence of this soil type indicates use of non-native and/or highly-disturbed backfill soils utilized during the construction of the PRGS facility;
- Below approximately 20 ft bgs, a transition to native fluvial soil intervals is noted. The native soils are comprised of gravel, sandy clays to clayey sands and sand zones and correlate to the associated Shirley Formation mapped for the site;
- Both the LIF soil conductivity data and field description of borings confirm the presence of a consistent fine grained lithologic feature beginning at approximately 25 ft bgs (Upper Site borings) with a thickness ranging from 2 to 6 feet. This feature, typically described as lean clay, exists within several feet above the observed top of water table. Evaluation of PID and LIF characterization data notes that many borings indicate impact exclusively or predominately above



the feature (example B-08, B-11). Several borings, however, note the response curves existing both above and below the clay feature (example B-51, B-30); and

- The December 2013 LIF survey denoted both the lateral and vertical extent of the hydrocarbon plume existing both at the PRGS (“Upper Site”) and the neighboring and down gradient NPS property (“Lower Site”). An aerial map projection of the LIF response can be referenced in the February 14, 2014 URS SCRA Report. Conclusions from the SCRA Report are as follows:
  - LNAPL response was described as a “diesel-like” oil signature;
  - Elevated LNAPL response in the Upper Site was noted for 16 of 27 total boreholes that completed to the target depth of 36 ft bgs;
  - LNAPL response in the Upper Site reached a maximum value of 396% Relative Emittance (RE) (PRGS UV-05). Depth of response (for this particular LIF boring) was indicated between 20 to 36 ft bgs;
  - Sixteen LIF borings in the Upper Site exceeded 100% RR indicating “substantial LNAPL phase or free product”. It is also possible that this degree of observed product saturation could exist in a residual and immobile state depending on the limitations imposed by pore space characteristics of the impacted lithology;
  - The greatest LIF responses occur in proximity to the UST area and decreased in distance from the UST structures. (It was noted that the LIF delineation was limited to the west and east areas of the Upper Site due to buildings and infrastructure.);
  - The Lower Site was penetrated with ten total LIF borings to a target depth of 20 to 30 feet. The Lower Site LIF borings were placed in close proximity to each other;
  - No Lower Site LIF responses exceeded 100% RE and the depth of response at the Lower Site was noted to range between 5 and 11 ft bgs; and
  - It was concluded that the LIF signatures between the Upper and Lower Sites were similar (diesel-like hydrocarbon) and likely represented the same plume.

## 5.2 Site Hydrogeology

### 5.2.1 Shallow and Deep Zone Monitoring

As noted in previous sections of this report, the PRGS groundwater monitoring well network has expanded from the initial 14 “TW”-series wells installed in December 2013 to the recently completed (July-August 2014) network comprised of 47 total wells.

In addition, the revised PRGS monitoring network now consists of co-located or stand-alone shallow wells terminating at depths between 25 and 27 ft bgs. The purpose of the shallow screen wells (designated with an “S”) was to screen and monitor above the observed clay layer feature without breaching the feature. Because the clay layer is positioned several feet above the top of the observed water table, the shallow wells were expected to intercept temporal groundwater that might be present either due to a



perched water condition following periods of extended precipitation and/ or during periods of excessively high water table height, when the clay layer might become submerged.

Information on the construction of all wells within the PRGS groundwater monitoring network is presented in the Well Construction Details Summary as **Table 2**. For discussion purposes, a brief table presenting the fluid-levels measurements for the new shallow wells (collected August 25, 2014), in comparison to their associated deeper well counterparts (when applicable), is presented below:

Well	GW Elevation (ft msl)	Product Thickness (ft)	Total Depth (ft bgs)
MW-01S	8.60	--	27
MW-08S	9.37	--	25
MW-10S	9.18	--	27
MW-15S	6.21	--	26
MW-16S	6.49	--	25
MW-16	4.42	--	36
MW-25S	9.09	--	26
MW-25	4.24	0.15	35
MW-30S	5.88	--	26
MW-51S	9.47	--	25.5
MW-51	4.38	Sheen	37
MW-72S	9.22	--	25
MW-72	4.40	--	35
MW-100S	9.75	--	24.5
MW-100	4.52	--	37.5
MW-109S	9.21	--	13.5
MW-109	4.57	--	24
MW-110S	9.08	--	13
MW-110	4.81	--	24
MW-112S	8.93	--	13
MW-112	4.55	--	24

In summary, it is noted that the eight co-located shallow and deep well sets now comprising the well network currently exhibit differing water level elevations by several feet. This indicates, with relatively consistency, that discrete shallow and deep screen zones have been established and that the clay feature appears to significantly impair communication between the two zones. Additional fluid-level monitoring

is required to better understand the long-term characteristics of the two zones and will be addressed in the future CAPA and updated SCM.

#### 5.2.2 Groundwater Flow and Gradient Determinations for the Shallow and Deep Zones

Shallow and deep zone groundwater elevation contour maps, created from the August 25, 2014 gauging event, are attached as **Figures 8** and **9**, respectively. Upon review of the groundwater elevation contour maps, it is observed that the shallow groundwater flow moves east to northeast from the facility toward the Potomac River. The shape of shallow groundwater dispersion is semi-radial in pattern, likely based on the artificially-extended riverbank position of the facility. The semi-radial dispersion pattern, however, is truncated by the screen/pump house building. This shallow zone groundwater flow pattern generally correlates to the dispersion pattern of dissolved TPH-DRO as presented in **Figure 5**. Groundwater gradients have been calculated between several shallow zone wells pairs and are summarized as follows:

- MW-25S to MW-15S = 0.05 ft/ft
- MW-08S to MW-30S = 0.05 ft/ft

The deep zone groundwater elevation contour map (**Figure 9**) demonstrates a predominant groundwater flow direction to the east-northeast for the areas north of the screen/pump house structures. A prominent deep zone groundwater mound is noted south of the screen/pump house structures in Zone 5S. It is noted that well deep well TW-02 and MW-05 were not included in the deep-zone groundwater elevation contour map based on an anomalous values. Groundwater gradients have been calculated between several deep zone well pairs and are summarized as follows:

- MW-51 to TW-06 = 0.007 ft/ft
- MW-51 to MW-31 = 0.0008 ft/ft

As presented in the deep zone TPH-DRO isoconcentration map, the apparent LNAPL thickness “footprint” extends between deep zone wells MW-05, MW-51 and MW-25 which are east and proximal to the 25,000-gallon fuel oil USTs. The northeast-southwest trending shape of the LNAPL thickness footprint correlates to both the dissolved TPH-DRO plume and the groundwater elevation contours generated for the deep-zone wells.

### 5.3 **Structural Barriers and Pathways**

Section 4.2 describes the construction characteristics of the bulkhead, screen house, and pump house. These structures serve as barriers to groundwater migration as they are installed across the groundwater table. Groundwater is sealed from the screen house by the sheet piles that surround the structure. The pump house, partially built over the screen house, is constructed above the normal groundwater table. Groundwater from beneath the UST area is flowing northeast and is first obstructed by this sheet pile bulkhead. Although the sheet piling serves as a barrier to flow for groundwater, it likely does not cause artificial groundwater mounding as the sheet piling is not set into a confining unit, and groundwater

maintains an equilibrium with the Potomac River. This also indicates that groundwater beneath the UST area and around the screen house is subject to tidal fluctuations. Construction plans for a sixth water intake structure, north of the screen house suggest that sheet piling may further extend north from the screen house structure creating additional potential barriers to flow. A trench to transport screened materials from the screen house extends south from the screen house as shown on **Figure 2 and Figure 7 (Site Plan and Sections)**. This trench likely creates a barrier to groundwater flow only during periods when the groundwater table is elevated.

The sheet piling creates a barrier to groundwater and LNAPL migration because the sheet piling extends above the groundwater table and therefore above the top of potential LNAPL that is present.

#### **5.4 Identified Preferential Pathways**

Three stormwater drains extend from the UST area through the bulkhead and served as permitted outfalls (Outfalls 003, 009, and 010) during the operational period of the power plant. The conveyance piping is buried below ground. Typically, gravel is used to backfill around the pipes which could act as a preferential pathway for groundwater migration and potentially for LNAPL. The pipes have been closed and sealed with a blank flange (Outfall 003 and 009) and low permeability grout (Outfall 003) and do not continue to flow. If the bulkhead is backfilled with rip-rap as the design drawings suggest, this may also be a preferential pathway for lateral migration of groundwater until the intersection of the bulkhead with the poured concrete foundation of the screen house. Design drawings indicate that the north section of the bulkhead was backfilled with rip-rap.

As presented in Section 4.8, the outside of the bulkhead was inspected with an thermal imaging camera to identify possible seeps from the bulkhead. Of the six potential seeps previously identified, three are associated with areas around the outfall pipes and could represent preferential pathways for groundwater flow and migration. The elevations of all the seeps are below the groundwater table immediately behind the bulkhead. This indicates that while the seeps are potential pathways for groundwater migration, they are likely not preferential pathways for LNAPL which may be present behind the bulkhead, although none has been detected to date in the monitoring wells.

#### **6.0 REMEDIATION ASSESSMENT**

Various remediation technologies have been screened to determine the most appropriate method or methods to remediate the liquid-phase, dissolved-phase and adsorbed-phase hydrocarbons that exist in the subsurface. Remedial technologies selected for consideration are based on the site-specific conditions mentioned above, including the monitoring well installation activities, groundwater sampling and gauging activities, tidal influence evaluation, pumping study activities, risk assessment, bulkhead integrity assessment, and historic Site activities.

The potential remedial technologies and site-specific factors associated with each are discussed below. The technologies have been evaluated based on their effectiveness in addressing each of the following aspects of the remedial strategy for the Site:



- Protection of the river;
- Source area remediation;
- Extended in-situ remediation; and
- Sustainability.

## **6.1 Bulkhead Seep Sealing**

Based on the initial evaluation of the bulkhead, potential seeps have been discovered along the wall that could create a pathway for petroleum hydrocarbons to reach the river. Sealing different areas of the wall where seeps are observed or suspected is considered a potentially viable technology at this site for protection of the river. The bulkhead acts as an effective physical barrier to LNAPL discharging to the river, and if seeps to the river can be minimized or eliminated, a remedial strategy can be utilized at the Site that does not involve hydraulic control of the contaminant plume or a barrier to contaminant migration.

## **6.2 Pump & Treat (P&T) or Total Fluid Extraction (TFE)**

Conventional P&T systems use pneumatic or electric submersible pumps to extract fluids from recovery wells. P&T is a practical remedial technology at the Site to gain hydraulic control, to retard downgradient migration of liquid-phase and dissolved-phase hydrocarbons, and to recover LNAPL. Because the pumps must be positioned below the water table, P&T cannot be implemented at shallow wells with less than a few feet of water column. The installation of an interception trench close to the source area could also be utilized to reduce contaminant migration and recover LNAPL and groundwater from both the water table and perched water zones. The interceptor trench would have a collection manhole that would receive fluids from the trench and convey them to the treatment system via a submersible pump or pumps.

P&T as a stand-alone remediation technology may require several years of system operation and maintenance to achieve cleanup. P&T is considered a potentially viable technology at this site, but would likely be less efficient than other technologies considering the large area and the high groundwater flow rate that would be required to make the technology effective. However, P&T could be effective in the initial phases of remediation to recover LNAPL and impacted groundwater prior to or along with implementation of a long term remedial strategy.

## **6.3 Soil Vapor Extraction (SVE)**

SVE is an in situ remedial technology that is effective in removing volatile constituents from the vadose zone. SVE systems utilize blowers to apply vacuums at extraction wells, allowing for the recovery of soil vapors from unsaturated soils. As air moves through contaminated soils in the vadose zone, VOCs, including adsorbed-phase hydrocarbons, are transferred into the vapor stream for recovery. SVE systems also promote aerobic bioremediation as soil gas from outside the impacted area with greater oxygen content is introduced.

For SVE to be successful, the soil must be sufficiently permeable to permit airflow, and the volatility of the constituent to be removed must be sufficiently high. While not all diesel range organics are sufficiently volatile to be recovered with SVE, SVE can still be an effective technology to greatly reduce the total hydrocarbon mass and to reduce the mobility and promote aerobic degradation of hydrocarbons remaining in the subsurface. Based on the well installation activities, there is a significant contaminant presence above the water table in the source area, and it is appropriate to evaluate SVE as a potential technology for this Site. However, the mixture of higher and lower permeability zones causing preferential pathways and the presence of perched groundwater could prevent optimal SVE recovery. Feasibility testing can evaluate the applicability of SVE for removing adsorbed-phase hydrocarbons from the vadose zone, and determine the ROI. SVE is considered a potentially viable technology. However, because of the impact in the saturated zone, utilizing SVE is not considered as a stand-alone technology, but rather in conjunction with another technology.

#### **6.4 Vacuum Enhanced Groundwater Extraction (VEGE)**

Vacuum enhanced groundwater extraction (VEGE) combines soil vapor extraction (SVE) and total fluids extraction. SVE systems utilize blowers to apply vacuums at extraction wells, allowing for the recovery of soil vapors from unsaturated soils. In addition, the application of vacuum to an extraction well creates pressure gradients that enhance LNAPL and groundwater recovery and also serves to remediate previously-saturated (i.e., prior to fluids recovery) zones. A VEGE system typically uses pneumatic submersible pumps to extract fluids and a blower to extract soil vapors. Soil vapors and fluids are extracted independently, and a range of vacuums can be applied depending on the formation to optimize recovery. VEGE is considered a viable option and could effectively recover adsorbed-phase hydrocarbons (both above and below the water table) and dissolved-phase hydrocarbons and LNAPL, especially in the short term. Over time, however, VEGE would likely be less efficient than other technologies considering the large area, the off-gas treatment requirements, and the high groundwater flow rate that would be required to make the technology effective.

#### **6.5 Air Sparge / Soil Vapor Extraction (AS/SVE)**

AS/SVE involves the delivery of compressed air into wells that are screened below the water table. Air bubbles travel upward and outward in the aquifer, resulting in the mass transfer of adsorbed-phase and dissolved-phase hydrocarbons into the vapor stream. Typically, the volatilized compounds are removed from the vadose zone by an SVE system. Air sparging also enhances aerobic biodegradation by introducing ambient air that typically has higher oxygen content than the soil gas within the impacted subsurface. Air sparging is most effective at sites with volatile contaminants and a permeable aquifer matrix. Stripping the volatile compounds from the groundwater (and LNAPL where applicable) is an effective approach to reduce groundwater concentrations and the presence of LNAPL. While not all diesel range organics are sufficiently volatile to be transferred into the vapor stream, air sparge can still be an effective technology to greatly reduce the total hydrocarbon mass and to reduce the mobility and promote aerobic degradation of hydrocarbons remaining in the subsurface.

The soil investigation and pumping study suggest that much of the saturated zone has sufficient permeability for effective air injection. However, the vadose zone appears to have some lower permeability zones and perched water. Air sparge would not be effective at remediating perched water, and applying vacuum above perched water would not be effective at capturing sparged vapors. Feasibility testing can further evaluate the effectiveness of air sparge, including how best to apply SVE to the subsurface in order to maintain vacuum influence and effectively capture sparged vapors.

AS/SVE is considered a potentially viable remedial option to improve the expected duration of active remediation at this Site compared with other technologies. In addition, the enhancement of aerobic biodegradation associated with air sparging is an important benefit that could expedite a transition to a longer term in-situ remedial strategy like biosparge. With the injection well infrastructure and air injection equipment, an AS/SVE system could be converted to a biosparge system once the presence of LNAPL is eliminated and SVE recovery is reduced.

## **6.6 Biosparge / Aerobic Bioremediation**

Biosparge relies on indigenous microorganisms to reduce contaminant levels and involves the delivery of compressed air into wells screened below the water table and at a low flow rate (i.e., compared with air sparging). Air bubbles travel upward and outward in the aquifer, resulting in increased DO levels for microorganisms. The basic requirements for aerobic degradation include a food source (petroleum), oxygen, and major nutrients (i.e., phosphorous and nitrogen). A blower is typically used to inject short cycles of compressed air into the saturated zone via short screened injection wells installed below the water table. As the compressed air enters the subsurface it expands and moves through the soil, resulting in increased DO levels for microorganisms, and exposing trapped LNAPL to air promoting dissolution and volatilization. No vapors requiring treatment are produced during biosparge.

For a sufficiently permeable soil matrix, this technology is appropriate for remediating groundwater with low to moderate petroleum concentrations. The soil conditions at the Site should allow for effective transport of oxygen throughout the on-site area of impact. Air injection feasibility testing, along with an analysis of groundwater quality parameters, can be used to further evaluate the applicability and potential effectiveness of biosparge. Based on the presence of LNAPL and the current hydrocarbon concentrations observed at this Site, aerobic bioremediation would require a considerable amount of time as a stand-alone remedy. Due to the timeframes involved, contaminant migration may not be controlled initially, and the sparging may cause contaminant migration and dissolved-phase concentrations to increase over the short-term. The higher sparge rate and VOC volatilization associated with air sparging may be more appropriate while some LNAPL exists in the subsurface and dissolved-phase hydrocarbon concentrations are significantly elevated, and an air sparge system could be designed for an efficient transition to a biosparge system at a later time.

## **6.7 Soil Excavation**

This remedial option requires the excavation and removal of impacted soil for on-site or off-site treatment. A majority of the soil impacts are located greater than 17 ft bgs. Excavation stabilization (e.g.,



shoring, sheeting) and dewatering would be needed to successfully achieve the depth required to remove the impacts. Soil excavation is not considered a viable technology at this time to remediate the impacted soil due to the volume of soil that would need to be removed, the presence of the existing Site infrastructure, and associated dewatering and excavation stabilization required. However, this remedial option could be evaluated in the future if Site activities change to allow more efficient access to the impacted soils.

## **6.8 Bioslurping**

Bioslurping involves the simultaneous application of vacuum enhanced extraction/recovery, vapor extraction, and bioventing to address LNAPL contamination. Liquid (product and groundwater) removed through the slurp tube is sent to an oil/water separator, and vapors are sent to a liquid vapor separator. Vacuum extraction/recovery is used to remove free product along with some groundwater, vapor extraction is used to remove high volatility vapors from the vadose zone, and bioventing is used to enhance aerobic biodegradation in the vadose zone and capillary fringe. The bioslurping system is made up of a well into which an adjustable length “slurp tube” is installed. The slurp tube, connected to a vacuum pump, is lowered into the LNAPL layer, and pumping begins to remove free product along with some groundwater (vacuum enhanced extraction/recovery). The vacuum-induced negative pressure zone in the well promotes LNAPL flow toward the well and also draws LNAPL trapped in small pore spaces above the water table. When the LNAPL level declines slightly in response to pumping or tidal fluctuations, the slurp tube begins to draw in and extract vapors (vapor extraction). This removal of vapors promotes air movement through the unsaturated zone, increasing oxygen content and enhancing aerobic bioremediation (bioventing). When tidal fluctuations or mounding due to the introduced vacuum causes a slight rise in the water table, the slurp cycles back to removing LNAPL and groundwater.

Bioslurping could be effective for removal of LNAPL and remediation of unsaturated or occasionally saturated soils from shallow monitoring wells where other technologies are less feasible, in perched water zones, or in areas where dissolved-phase hydrocarbons are of reduced concern. However, this technology would be less effective where significant dissolved-phase hydrocarbons exist, because of the limited groundwater recovery during bioslurping. Bioslurping could be effective in the initial phases of remediation or to remediate shallow wells with perched groundwater.

## **6.9 Enhanced Fluid Recovery (EFR)**

Enhanced Fluid Recovery (EFR) event requires the use of a vacuum extraction truck, a recovery well, and drop tube (stinger). The events are very high intensity for a short duration. LNAPL is recovered by fitting the recovery well with a stinger positioned just above the water table and vacuuming the LNAPL and top of the water table into the truck. EFR events are an effective method to recover measurable amounts of LNAPL and impacted groundwater and as a means to control the source of the LNAPL. In addition to LNAPL and groundwater recovery, this method can be used to biovent the vadose zone and dewatered saturated zone enhancing oxygen content and thus promoting natural aerobic biodegradation. The EFR events in the source area would likely occur using the existing monitoring well network.



EFR events are not viable as a stand-alone remediation technology, but are considered a potentially viable technology at this Site for reduction of LNAPL or to remediate shallow wells with perched groundwater. EFR events could be effective in the initial phases of remediation to recover LNAPL and groundwater prior to or along with implementation of a long term remedial strategy.

#### **6.10 In-Situ Chemical Oxidation (ISCO)**

ISCO introduces an oxidant into the subsurface, breaks the chemical bonds of organic compounds, and yields innocuous by-products determined by the type and strength of the oxidant. An injection pump is used to dispense a known volume and concentration of a selected oxidant into the subsurface through temporary or dedicated injection points. The options for the chemical oxidant include hydrogen peroxide, ozone, sodium persulfate, and sodium percarbonate. Low pressure air injection can be used in conjunction with ISCO to aid in dispersing the chemicals and provide additional oxygen for enhanced biodegradation of hydrocarbons. Combinations of oxidants can also be utilized. Hydrogen peroxide reacts with ozone and/or iron in the subsurface to form the hydroxyl radical (OH•). With this hydroxyl radical, dissolved and adsorbed hydrocarbons have relatively high reaction rate constants and readily break down through this process. Sodium persulfate reacts with activators to form the sulfate radical (SO<sub>4</sub>•). This reaction mechanism is similar to the hydroxyl radical and can further reduce the dissolved-phase and adsorbed-phase mass. Heat and iron-ethylenediaminetetraacetic acid (EDTA) are conventional methods for activation, and hydrogen peroxide can also be used for an aggressive remedial option. Sodium persulfate can be applied in concentrated form since it is very soluble, and while its reactivity is similar to peroxide, it is much more stable.

The oxidation processes described also promote bioremediation due to significant increases in dissolved oxygen that typically occur from the oxygen/air injection, reactions that produce oxygen, and break down of ozone and hydrogen peroxide and sodium persulfate.

ISCO can be a viable approach in treating impacts at or below the water table. Higher permeability soils are necessary to achieve a large ROI around each injection well. ISCO may be limited in areas where fine grained soils exist at and below the water table. The high concentrations in the areas of impact at this Site suggest that high chemical quantities and either long-term injection events or multiple short-duration injection events over a series of years may be required to reduce contaminant concentrations to acceptable levels. ISCO is not recommended at this time. However, ISCO may be considered following contaminant concentration reduction by another active remediation technology.

#### **6.11 Monitored Natural Attenuation (MNA)**

MNA relies upon natural subsurface processes to reduce contaminant concentrations to acceptable levels. As stated in OSWER Directive 9200.4-17P, 1999, “the natural attenuation processes that are at work in such a remediation approach include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These in-situ processes include biodegradation;

dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of contaminants.” (p. 3)

The contaminants at the Site are known to naturally attenuate. However, based on the dissolved concentrations and associated time frame to meet remedial objectives, monitored natural attenuation as a stand-alone technology is not a recommended remedial alternative at this time. Natural attenuation may be considered in some areas of the Site or once contaminant concentrations have been further reduced. Monitoring for groundwater quality parameters and indicators of anaerobic biodegradation processes can be completed to further characterize the subsurface and determine the potential for MNA or bioremediation to be effective.

## 6.12 Enhanced Anaerobic Bioremediation

Enhanced Anaerobic Bioremediation relies on indigenous microorganisms to reduce contaminant levels, but in the absence of oxygen. In this case, compounds like sulfate, nitrate, or iron are used as electron acceptors injected into the subsurface to reduce petroleum hydrocarbon concentrations. For a sufficiently permeable soil matrix, this technology may be appropriate for remediating groundwater with low to moderate petroleum concentrations. Injection feasibility testing, along with an analysis of groundwater quality parameters, can be used to further evaluate the applicability and potential effectiveness of this technology. However, based on the concentration levels observed at this Site as well as the significant impacts in the vadose zone, enhanced anaerobic bioremediation is not viable as a stand-alone remedy. While a more aggressive approach is recommended in the area of highest impacts, electron acceptor applications could be beneficial in less impacted areas of the Site or as a polishing technology. Monitoring for groundwater quality parameters and indicators of anaerobic biodegradation processes can be completed to further characterize the potential for bioremediation.

## 6.13 Remediation Assessment Summary

The preceding Sections 6.1 through 6.12 present remedial technologies that used alone or in combinations could be effective at addressing the site contaminants. The following table summarizes the evaluation assessment for each technology and indicates whether or not the identified technology will be retained for further evaluation. This further evaluation will consist of feasibility testing, and or direct implementation.

Remedial Technology	Retained for Further Evaluation	Assessment
Bulkhead Seep Sealing	Yes	Viable technology to act as physical barrier; Will be retained for further evaluation but will be evaluated in conjunction with other source/mass reduction methods
Pump and Treat/Total Fluid Extraction	Yes	Effective technology that will be retained for further evaluation; Is most effective when combined with other technologies such as vacuum enhancement
Soil Vapor Extraction	Yes	Effective technology that will be retained for further



Remedial Technology	Retained for Further Evaluation	Assessment
		evaluation (unsaturated soils only); Is most effective when combined with other technologies such as groundwater pumping
Vacuum-Enhanced Groundwater Extraction	Yes	Effective combination of technologies; Will be retained for further evaluation
Air Sparge/Soil Vapor Extraction	Yes	Effective combination of technologies; Will be retained for further evaluation
Biosparge / Aerobic Bioremediation	Yes	Effective technology for low-level dissolved phase concentrations; Retained for further analysis in downgradient locations only
Soil Excavation	No	Not retained for further evaluation at this time; technically feasible but would require significant effort to implement and will not effectively address groundwater
Bioslurping	Yes	Effective technology to address discrete areas of LNAPL; Will be retained for further analysis
Enhanced Fluid Recovery	No	Effective technology that is appropriate for short-term or interim use; Not retained for full scale analysis but may be used as an interim measure
In Situ Chemical Oxidation	No	Not considered effective for fine-grained soils as found at this site; Not retained for further analysis
Monitored Natural Attenuation	No	Effective technology but likely will require many years to implement and may not effectively prevent discharge to river
Enhanced Anaerobic Bioremediation	No	Effective technology but likely will require many years to implement and may not effectively prevent discharge to river

## 7.0 CORRECTIVE ACTION IMPLEMENTATION AND SCHEDULE

Based on the comprehensive Site characterization activities conducted to date, it is recommended that a multistep approach to corrective action, including feasibility testing of multiple remedial technologies, characterization of biological activity in the subsurface through assessment of groundwater quality parameters, and additional assessment of contaminant migration in the vicinity of the bulkhead.

### 7.1 Feasibility Testing

As discussed above, various remedial technologies were screened to determine suitable remediation strategies to address the liquid-phase, adsorbed-phase and dissolved-phase hydrocarbons that exist in the subsurface. Based on the remediation considerations mentioned above, it has been determined that feasibility testing should include SVE testing of the shallow and deep unsaturated zones, air injection testing for air sparge or biosparge evaluation, VEGE testing, and total phase extraction testing. Total phase extraction testing will be performed to characterize the shallow monitoring wells with perched

groundwater and evaluate EFR events or bioslurping for the removal of LNAPL and groundwater from shallow monitoring wells where other technologies are not feasible.

It is proposed that a four to five day feasibility test be conducted. The primary objective of remedial feasibility testing activities is to determine the feasibility of the remedial technologies for the Site. Other specific feasibility testing objectives include determination of the following:

- Optimal injection and extraction flow rates;
- Optimal applied pressures and vacuums;
- ROI for each technology; and,
- Mass removal rates.

The feasibility test includes the tests detailed in the table below, at a minimum, but the specific tests and wells utilized for each test could change based on further data collection and evaluation. Recovery wells and sparge points will be installed to accomplish this testing.

Test	Description
1	SVE at shallow monitoring well (MW-25S or MW-10S)
2	SVE at deep monitoring well (MW-25)
3	SVE at proposed recovery well (RW-1)
4	AS at proposed sparge point (SP-1) and SVE (RW-1)
5	AS at proposed sparge point (SP-2) and SVE (RW-2)
6	VEGE at a proposed recovery well (RW-1)
7	TPE at a shallow monitoring well with perched groundwater (MW-10S)

#### 7.1.1 Feasibility Testing Well Installation Activities

Two recovery wells (RW-1 and RW-2) will be installed at the Site for SVE and VEGE feasibility testing, and two sparge points (SP-1 and SP-2) will also be installed for the purpose of air injection during air sparge testing. Two sets of each will be installed to evaluate the variability across different areas of the Site.

The purpose of the recovery wells is that the SVE wells penetrate to the water table and are screened in the shallow impacted soils, and that the VEGE wells are screened to allow SVE and groundwater extraction to effectively occur from one well. Recovery well RW-1 and sparge point SP-1 will be installed in the vicinity of monitoring wells MW-25 and MW-51, and recovery well RW-2 and sparge point SP-2 will be installed in the vicinity of monitoring wells MW-27 and MW-31. The recovery wells will be four-inch diameter PVC pipe and will each utilize continuous wrapped screen. The sparge points



will be two-inch diameter PVC pipe and will each utilize a three-foot continuous wrapped screen below the water table for air injection.

Actual injection well screen installation depths will be determined in the field during installation, but proposed well construction details are included below.

Well ID	Well Diameter (inches)	Screen Interval (feet bgs)
RW-1	4	~20-40
RW-2	4	~20-40
SP-1	2	~32-35
SP-2	2	~32-35

The proposed recovery wells and sparge points will be installed utilizing a Geoprobe® with HSA capabilities. Continuous soil samples will be collected during well installation documenting the lithology, physical characterization and field screening using a PID. At a minimum, the soil sample exhibiting the highest PID reading and the soil sample collected at the apparent soil-groundwater interface from each boring will be submitted for laboratory analysis. Additional soil samples may be collected and submitted for laboratory analysis for vertical delineation. Each collected soil sample will be analyzed for TPH-DRO by EPA Method 8015.

#### 7.1.2 Feasibility Testing Activities

During testing, the applied vacuums, air flow rates, influent VOC concentrations, and groundwater extraction flow rates are to be monitored during testing. Vapor monitoring is to be conducted using a PID and induced vacuum responses and groundwater level fluctuations are to be collected at designated observation wells surrounding the extraction wells using transducers and wireless transmitters available on the DAPL. Additional groundwater parameters will be collected from observation wells during AS/SVE testing using a multi-parameter water quality meter. During VEGE testing, groundwater will be extracted from a groundwater monitoring well utilizing a top loading pneumatic pump. At the conclusion of testing, additional monitoring will be conducted as site conditions returned to static levels.

Vapor samples for laboratory analysis will be collected during SVE and TPE testing from the recovered vapor stream. Samples are to be analyzed for BTEX, TPH C<sub>1</sub>-C<sub>4</sub> hydrocarbons, and TPH >C<sub>4</sub> to C<sub>10</sub> hydrocarbons via EPA method 18. Water samples for laboratory analysis will be collected during VEGE testing from the recovered groundwater. Water samples will be analyzed for BTEX via EPA method 8260 and TPH-GRO and TPH-DRO via EPA method 8015. Metal constituents (total/dissolved calcium, total/dissolved iron, total/dissolved magnesium, total/dissolved manganese and total lead) will be analyzed via EPA method 6010. Oil & grease will be analyzed via EPA method 1664, and total dissolved solids (TDS) and total suspended solids (TSS) will be analyzed via EPA method 2540.

#### SVE:



An SVE step test will be conducted to start extraction from each extraction well. The vapor flow rate, vapor phase hydrocarbon recovery rate, vacuum ROI, and water mounding in surrounding wells at different vacuums will be determined during the SVE-only phases of the event. Vapor flow, vacuum influence, and VOC concentration data will be collected at each vacuum step. The vacuum level may need adjustment to ensure that water is not pulled from the well. This may result in a reduced number of SVE steps. The following is typical of a vacuum step test:

1. Step 1: 20 i.w.
2. Step 2: 40 i.w.
3. Step 3: 60 i.w.
4. Step 4: 100 i.w. (or maximum vacuum for blower used), if appropriate for site conditions (this step would replace a lower vacuum step)

#### AS/SVE:

During AS testing, the sparging pressure will be determined at different sparge flow rates. In addition, the pressure influence, upwelling, headspace VOC concentrations, and the dissolved oxygen (DO) in surrounding observation wells will be determined, and the vapor recovery flow rate, vacuum ROI, vapor phase hydrocarbon recovery rate, and water recovery rate (if any) will be determined while SVE is being applied. An air sparge step test will be conducted at each sparge point prior to AS/SVE testing. Pressure will be increased at low sparge flow rate until the breakout pressure is reached. Air will then be injected at varying flow rates. The following is an example of the flow rate steps:

- i) Step 1: 3 scfm
- ii) Step 2: 5 scfm
- iii) Step 3: 7 scfm

#### VEGE:

A submersible groundwater pump will first be used to pump groundwater from the extraction well without vapor extraction. This phase of testing will determine the approximate groundwater extraction rate necessary to obtain maximum drawdown in the absence of vacuum enhancement. This effort will also dewater local sediments to expose hydrocarbon impacted soils and improve the performance of subsequent VEGE testing. VEGE operation will then occur on the extraction well. The vacuum during VEGE operation will be field determined based on an evaluation of SVE-only testing. If conditions suggest that a change in vacuum could provide a benefit, multiple vacuums will be evaluated. The vacuum range noted in the SVE test (up to 100 i.w.) is anticipated during VEGE testing. The mobile platform will have a blower capable of applying up to 28 inches of mercury of vacuum that could be used should a higher vacuum be necessary. During VEGE testing, the vacuum-enhanced groundwater recovery rate, vapor-phase hydrocarbon recovery rate, dissolved phase hydrocarbon recovery rate, and vacuum and groundwater ROIs will be determined.

#### TPE:

During TPE step testing, a drop tube will be installed in the well near the water table, and the maximum vacuum from the high vacuum, rotary claw blower will be applied to the well. The drop tube may be adjusted as necessary to ensure fluid and vapor is extracted from the well. The vapor flow rate, fluid

extraction flow rate, vapor phase hydrocarbon recovery rate, vacuum ROI, and groundwater drawdown or mounding in surrounding wells will be determined during TPE testing.

## 7.2 Interim Monitoring Plan

GES proposes that “gauge and bail” activities be conducted twice per month, groundwater sampling activities be conducted once per quarter, and groundwater samples collected from all monitoring wells be analyzed for TPH-DRO via EPA Method 8015.

In addition to VOCs, it is proposed that the following parameters be monitored from select wells during routine monitoring well sampling events to monitor biodegradation occurring at the site. Some of the parameters will also be used to characterize the groundwater in the shallow monitoring wells. A minimum of 10 wells will be monitored for these additional parameters, and both shallow and deep wells will be monitored.

Parameter	Purpose
Dissolved Oxygen (DO)	Primary electron acceptor for aerobic microbial respiration
Oxidation Reduction Potential (ORP)	ORP influences and is influenced by biological processes
pH	Biological processes are pH-sensitive
Temperature	Metabolism rates for microorganisms depend on temperature
Conductivity	Water quality parameter used to verify groundwater is representative of the larger groundwater system
Headspace VOC concentration	Indicator of the soil gas VOC concentration or methane production from anaerobic processes
Headspace CO <sub>2</sub> concentration	Indicator of anaerobic biodegradation processes
Nitrate (NO <sub>3</sub> <sup>-1</sup> )	Secondary electron acceptor for microbial respiration if oxygen is depleted
Ferrous Iron (Fe <sup>2+</sup> )	Indicator of anaerobic biodegradation processes
Sulfate (SO <sub>4</sub> <sup>2-</sup> )	Substrate for anaerobic microbial respiration
Methane	Indicator of anaerobic biodegradation processes

## 7.3 LNAPL Baildown Tests

LNAPL baildown tests will be performed on all wells containing LNAPL thicknesses which are, at a minimum, greater than the diameter of the borehole (i.e. a 4” well drilled with 8-inch augers will require at least 0.66 feet of measureable LNAPL). LNAPL baildown testing is designed to provide data for a quantitative analysis of the oil conductivity, hydraulic conductivity, and other soil properties that control oil saturations, volume, mobility, and recoverability.

The following procedures will be followed for LNAPL baildown testing:

- Measure the static fluid levels using an EIP once more and record the time.



- Insert the bailer slowly into the free LNAPL, making sure that its weight is increasing (that it is filling).
- Note the clock time, withdraw the bailer, and pour the contents into the calibrated bucket.
- Collect another bailer or two of fluids and note the clock time when the last bail is lifted out of the fluid column in the well.
- Pour the contents into the calibrated bucket and immediately start measuring depths to oil and water with the interface probe.
- Measure depths to the fluid interfaces at increasing time intervals as follows: 0.5, 1, 3, 5, 10, 20, 30, 40, 60, 90, 120, 240, 360, and 480 minutes.
- Note clock times, elapsed times, product thickness, and volumes of oil and water bailed
- Continue fluid level measurements until about 80% of the original thickness has returned to the well or until at least 6 hours has elapsed.

According to API publication 4711 (Sale, 2001), there are two commonly used methods for analyzing oil conductivity using baildown test data – those of Lundy and Zimmerman (1996) and Huntley (2000). Both of these analytical methods treat the baildown test as a slug test that induces LNAPL and groundwater to flow to a well after an LNAPL slug has been withdrawn. Both methods provide an estimate of the oil conductivity ( $K_o$ ) or transmissivity ( $T_o$ ) as determined by the rate of oil recovery after its removal from the test well (API, 2004). The Lundy-Zimmerman method also analyzes the hydraulic conductivity for the groundwater zone beneath the mobile LNAPL zone, determined by the rate of recovery of the corrected water table after bailing stops. A combination of the Lundy-Zimmerman and Huntley methods will be evaluated based on the field data results.

#### **7.4 EFR Remediation Events**

EFR remediation events are proposed as an interim remedial strategy for the Site. EFR events utilizing a vacuum truck will be performed on wells where baildown test analyses demonstrate that LNAPL transmissivity values are within the practical range of recoverability (e.g., 0.1 to 0.8 ft<sup>2</sup>/day) and a measurable LNAPL thickness of 0.5 feet or greater is observed. The objective of the EFR events is to perform a short-term, aggressive, total-phase extraction effort that is focused on recovery of hydrocarbon mass from the subsurface. However, additional data will be collected during the events to evaluate subsurface conditions for future remedial activities. The EFR events will encourage LNAPL to flow towards the extraction points, as well as increase natural biodegradation by encouraging vapor and fluid flow through the formation.

Each monitoring well used for extraction will be fitted with a well seal that allows the insertion of a drop tube for total phase extraction. The EFR events will draw down the water table in the immediate area around the extraction wells, pull vapors toward the wells, and encourage LNAPL flow toward the extraction wells. The proposed EFR events will utilize a mobile vacuum truck for total-phase extraction on the selected monitoring wells for a set period of time. The EFR events will be performed in the following manner:



1. Prior to the events, the surrounding monitoring wells will be gauged.
2. At the extraction wells, a drop tube will be installed through the modified well seal and set so that the bottom of the drop tube is just below the measured groundwater table.
3. The vacuum truck will extract from each monitoring well for a maximum period of 6 hours or until the truck has reached its capacity.
4. The extraction well drop tube depth will be adjusted as necessary throughout the event to optimize recovery.
5. While total phase extraction is occurring, the surrounding site monitoring wells will be monitored for liquid level changes and vacuum influence.
6. An air sample will be collected from each extraction well to determine the vapor-phase hydrocarbon recovery rate. The air samples will be screened with a PID and analyzed for BTEX via EPA Method 18 and TPH (C1–C4) and TPH (>C4–C10) by EPA Method 18.

Recovered fluids from the EFR events will be removed from the site and subsequently treated/disposed of by a Virginia-approved/licensed transport and disposal company.

## 7.5 Implementation Schedule

The following table presents the proposed schedule for CAP Implementation (CAPI):

Task / Deliverable	Schedule	Comments
Ongoing Monitoring	<ul style="list-style-type: none"> <li>Gauging &amp; Bailing 2x per Month</li> <li>Quarterly Groundwater Sampling</li> </ul>	or as directed by VDEQ
LNAPL Baildown Testing	<ul style="list-style-type: none"> <li>As LNAPL thickness allows</li> </ul>	LNAPL > 1/2 borehole diameter
Product Recovery / EFR	<ul style="list-style-type: none"> <li>As LNAPL thickness allows</li> </ul>	LNAPL > 0.5 ft and recoverable
Field Feasibility Testing	<ul style="list-style-type: none"> <li>45 days after VDEQ approval</li> </ul>	Recovery well & sparge wells installed and field feasibility testing complete.
Updated SCM	<ul style="list-style-type: none"> <li>60 days after VDEQ approval</li> </ul>	A revised and updated SCM will be provided prior to submission of the CAPA.
CAP Addendum	<ul style="list-style-type: none"> <li>90 days after VDEQ approval</li> </ul>	The CAPA will include the proposed remedial approach and implementation schedule.

## 8.0 CONCLUSIONS AND RECOMMENDATIONS

Various remediation technologies are being evaluated to determine the most appropriate method or methods to remediate the liquid-phase, dissolved-phase and adsorbed-phase hydrocarbons that exist in the subsurface. Remediation will be implemented based on site characterization activities conducted to date



that have included the monitoring well installation activities, groundwater sampling and gauging activities, tidal influence evaluation, pumping study activities, risk assessment, and retaining wall integrity assessment.

Crucial aspects of the remedial strategy for the Site include protection of the river, source area remediation, long-term in-situ remediation, and sustainability. As the remedial strategy is developed, a multistep approach to corrective action is suggested, including additional fluid-level monitoring to better understand the long-term characteristics of the shallow and deep zones, feasibility testing of multiple remedial technologies, analysis of the pumping study, characterization of biological activity in the subsurface, additional monitoring of contaminant migration, and LNAPL recoverability testing.

The following are elements to be summarized and addressed in the planned CAPA:

- Pump study analysis
- Remedial feasibility testing summary;
- LNAPL baildown testing summary;
- EFR events summary;
- Remedial goals;
- Selected remedial strategy;
- Operational and post operational monitoring schedule;
- Reporting schedule and distribution; and
- Public notification.

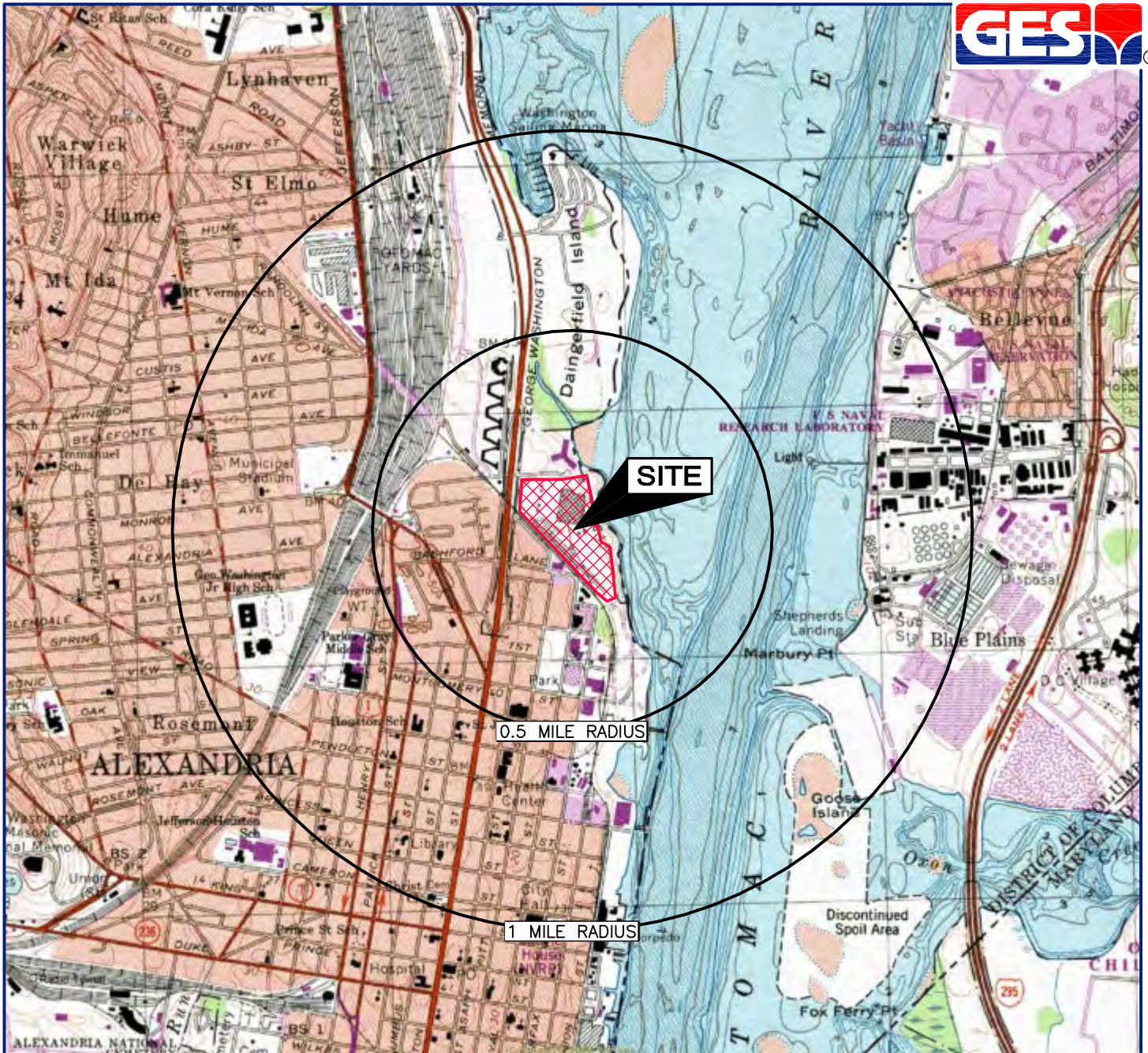
An updated SCM and CAPA will be submitted following these additional activities described above.



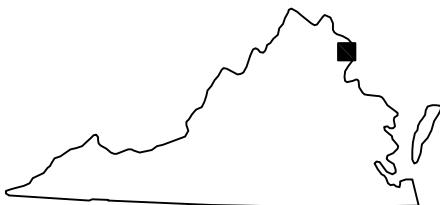
Geosyntec  
consultants

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## FIGURES





SOURCE: USGS 7.5 MINUTE SERIES  
TOPOGRAPHIC QUADRANGLE 1983  
ALEXANDRIA, VIRGINIA  
CONTOUR INTERVAL = 10'

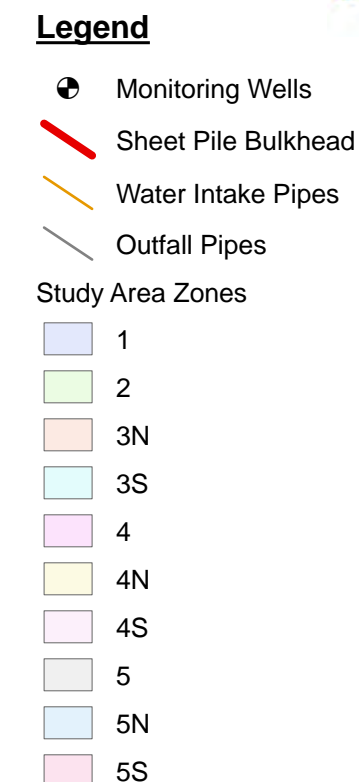




QUADRANGLE LOCATION

LAT. 10° 2' 3" N  
LONG. 10° 5' 6" W  
(APPROXIMATE SITE COORDINATES)

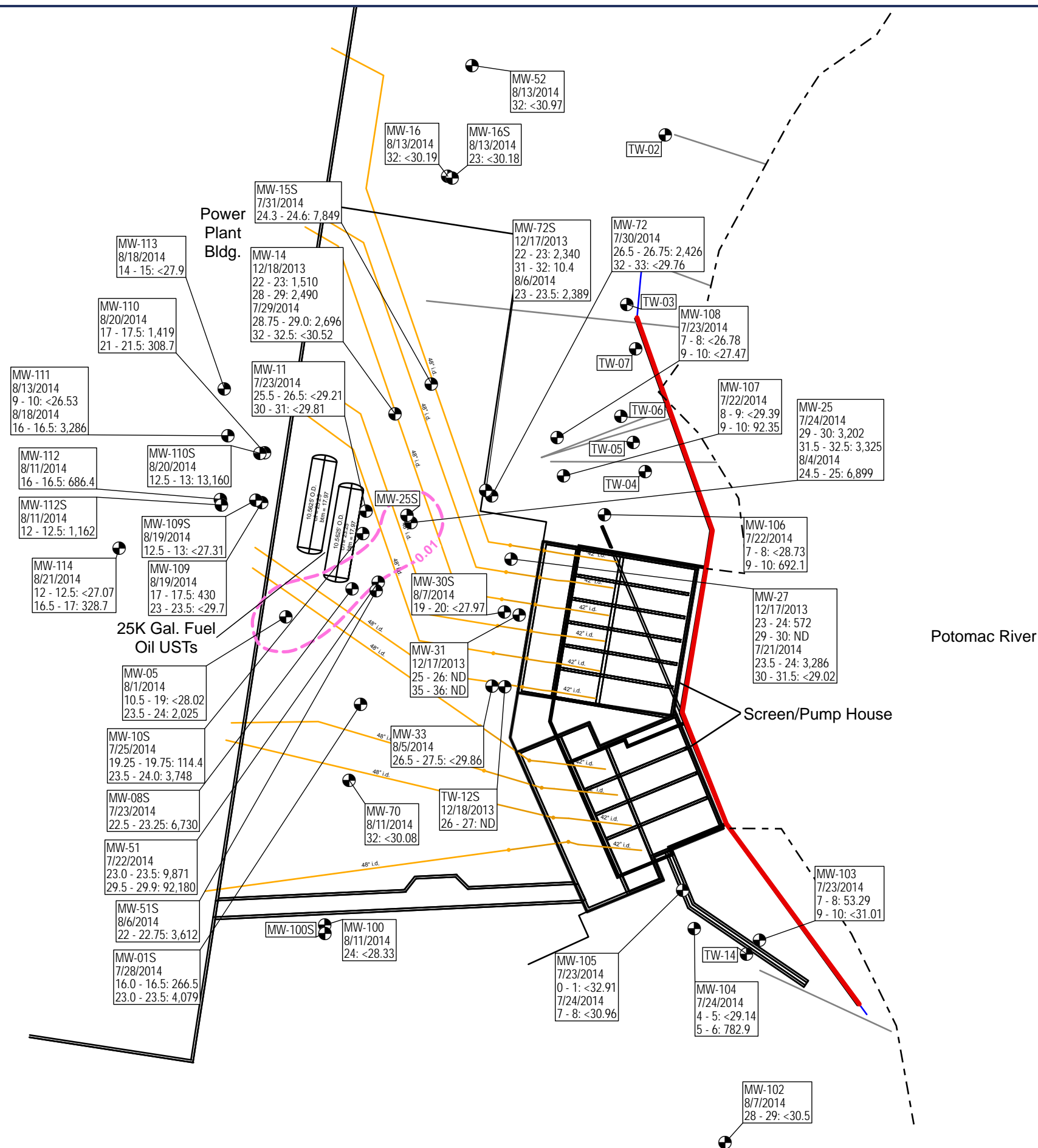
DRAFTED BY: W.A.W. (N.J.)	SITE LOCATION MAP		
CHECKED BY:	GEOSYNTEC CONSULTANTS, INC. POTOMAC RIVER GENERATION PLANT 1400 NORTH ROYAL STREET ALEXANDRIA, VIRGINIA		
REVIEWED BY:	Groundwater & Environmental Services, Inc. 1350 BLAIR DRIVE, SUITE A, ODENTON, MD 21113		
NORTH 	SCALE IN FEET  0 2000	DATE 8-22-14	FIGURE 1





DRAFTED BY: RAB	<h1>STUDY AREA MAP</h1> <h2>POTOMAC RIVER GENERATING STATION</h2> <h3>1400 NORTH ROYAL STREET</h3> <h3>ALEXANDRIA, VIRGINIA</h3>		
CHECKED BY: GR			
REVIEWED BY: SS			
NORTH 	Groundwater & Environmental Services, Inc. 1350 BLAIR DRIVE, SUITE A, ODENTON, MD 21113		
	SCALE IN FEET  0 50	DATE 9-4-14	FIGURE 3

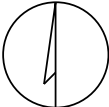

L:\Projects\GeoSyntec\PotomacPower\GenerationStation\GIS\PotomacRiver\GenerationStation\_TPH-DRO\_SO\_201408.mxd - Scale 1:900 - 9/4/2014 3:53:03 PM - RBannister - NAD 1983 StatePlane Virginia North FIPS 4501 Feet



### Legend

- Monitoring Wells
  - LNAPL Thickness (ft)
  - Property Boundary (Approximate)
  - Sheet Pile Bulkhead
  - Water Intake Pipes
  - Outfall Pipes
- Soil Sample Location**  
Sample Date  
Result (mg/kg)  
Sample Depth Interval (ft)
- MW-72S  
12/17/2013  
22 - 23: 2,340  
31 - 32: 10.4  
8/6/2014  
23 - 23.5: 2,389

Notes:  
Samples labeled with depth range in feet and TPH-DRO concentration in mg/kg.  
<# = Less than the Reporting Limit  
ND = Not Detected  
TPH-DRO = Total petroleum hydrocarbons - diesel range

DRAFTED BY: RAB	SOIL TPH-DRO CONCENTRATION MAP 12/17/2013 - 8/21/2014		
CHECKED BY: GR	POTOMAC RIVER GENERATING STATION 1400 NORTH ROYAL STREET ALEXANDRIA, VIRGINIA		
REVIEWED BY: SS	Groundwater & Environmental Services, Inc. 1350 BLAIR DRIVE, SUITE A, ODENTON, MD 21113		
NORTH 	SCALE IN FEET  0 50	DATE 9-4-14	FIGURE 4

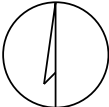

L:\Projects\GeoSyntec\PotomacPowerGenerationStation\GIS\PotomacRiverGenerationStation\_TPH-DRO\_GW\_201408\_Shallow.mxd - Scale 1:600 - 9/4/2014 4:48:28 PM - RBannister - NAD 1983 StatePlane Virginia North FIPS 4501 Feet



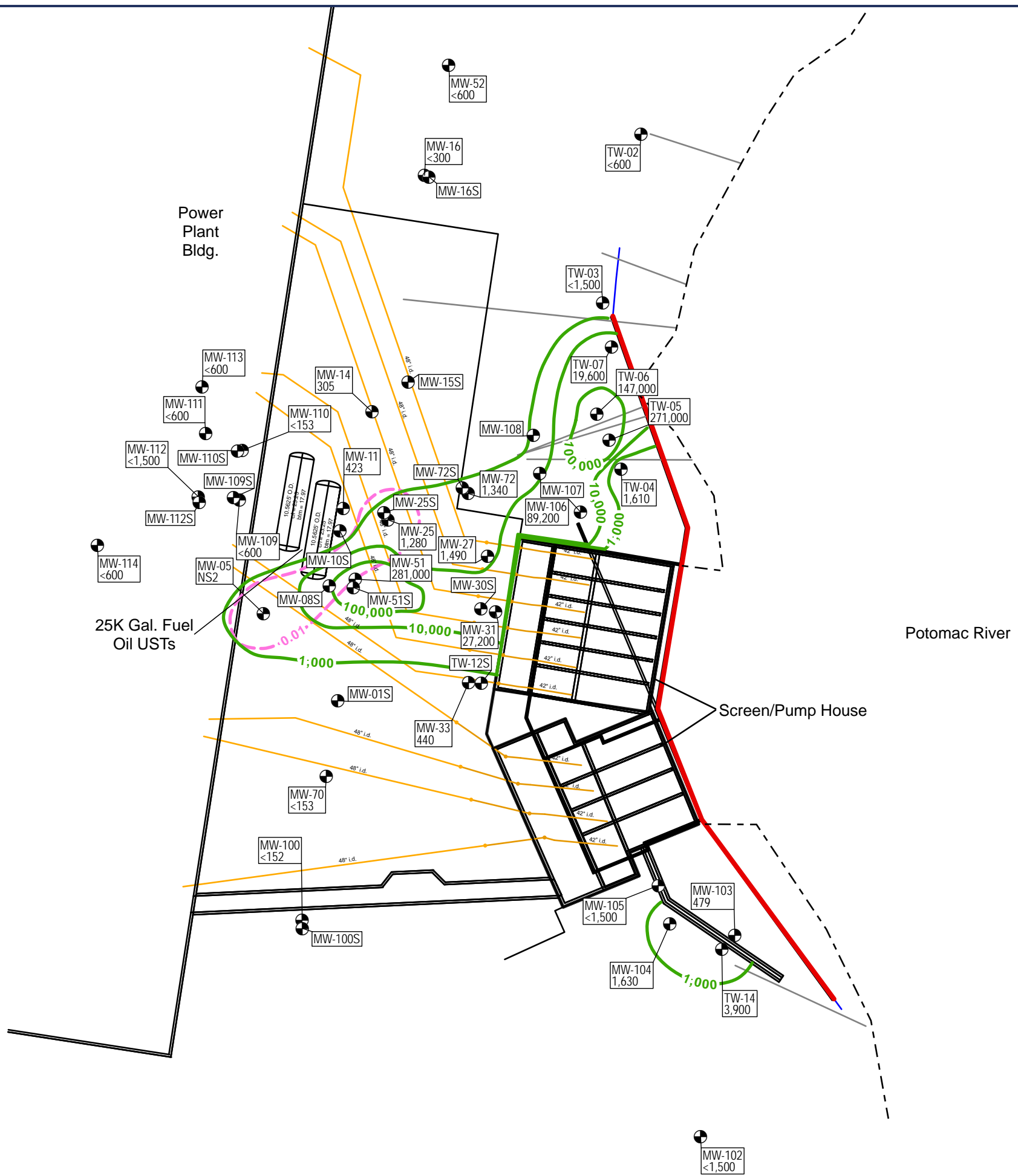
**Legend**

- Monitoring Wells
- TPH-DRO Isoconcentration Line (µg/L)
- LNAPL Thickness (ft)
- Property Boundary (Approximate)
- Sheet Pile Bulkhead
- Water Intake Pipes
- Outfall Pipes

Notes:  
Wells labeled with TPH-DRO concentration in µg/L.  
<# = Less than the Reporting Limit  
NS1 = Not sampled due to insufficient water volume  
NS2 = Not sampled due to presence of product  
TPH-DRO = Total petroleum hydrocarbons - diesel range

DRAFTED BY: RAB	GROUNDWATER TPH-DRO CONCENTRATION MAP SHALLOW ZONE, 8/13-25/2014		
CHECKED BY: GR	POTOMAC RIVER GENERATING STATION 1400 NORTH ROYAL STREET ALEXANDRIA, VIRGINIA		
REVIEWED BY: SS			
NORTH 	Groundwater & Environmental Services, Inc. 1350 BLAIR DRIVE, SUITE A, ODENTON, MD 21113		
	SCALE IN FEET 	DATE 9-4-14	FIGURE 5

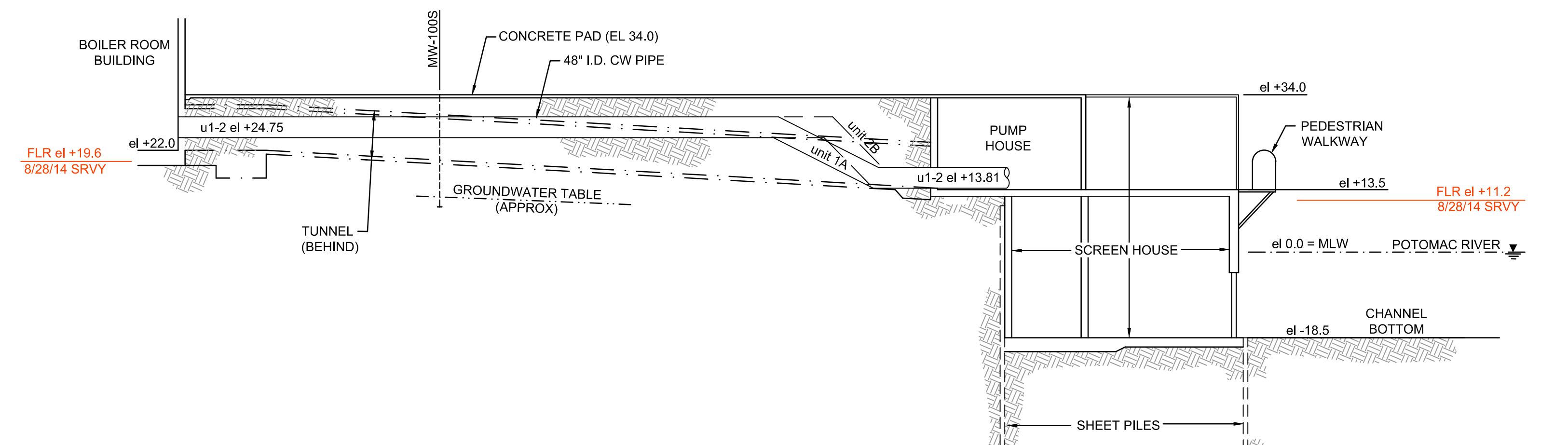
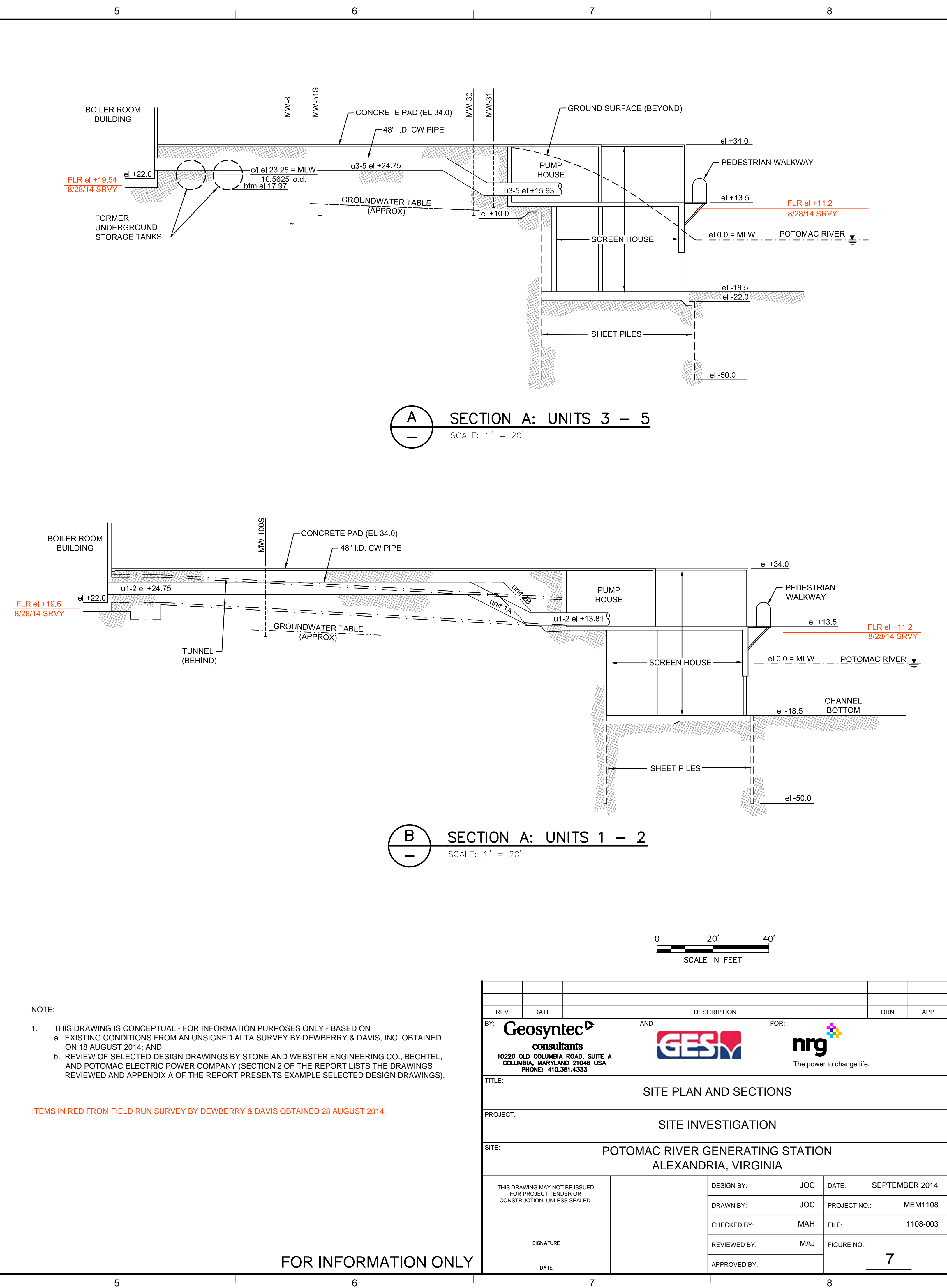
L:\Projects\GeoSyntec\PotomacPowerGenerationStation\GIS\PotomacRiverGenerationStation\_TPH-DRO\_GW\_201408\_Deep.mxd - Scale 1:600 - 9/4/2014 4:50:01 PM - RBannister - NAD 1983 StatePlane Virginia North FIPS 4501 Feet



- Legend**
- Monitoring Wells
  - TPH-DRO Isoconcentration Line (µg/L)
  - LNAPL Thickness (ft)
  - Property Boundary (Approximate)
  - Sheet Pile Bulkhead
  - Water Intake Pipes
  - Outfall Pipes

Notes:  
Wells labeled with TPH-DRO concentration in µg/L.  
<# = Less than the Reporting Limit  
NS1 = Not sampled due to insufficient water volume  
NS2 = Not sampled due to presence of product  
TPH-DRO = Total petroleum hydrocarbons - diesel range

DRAFTED BY: RAB	GROUNDWATER TPH-DRO CONCENTRATION MAP DEEP ZONE, 8/13-25/2014		
CHECKED BY: GR	POTOMAC RIVER GENERATING STATION 1400 NORTH ROYAL STREET ALEXANDRIA, VIRGINIA		
REVIEWED BY: SS			
NORTH 	Groundwater & Environmental Services, Inc. 1350 BLAIR DRIVE, SUITE A, ODENTON, MD 21113		
	SCALE IN FEET 	DATE 9-4-14	FIGURE 6



NOTE:

1. THIS DRAWING IS CONCEPTUAL - FOR INFORMATION PURPOSES ONLY - BASED ON  
a. EXISTING CONDITIONS FROM AN UNSIGNED ALTA SURVEY BY DEWBERRY & DAVIS, INC. OBTAINED ON 18 AUGUST 2014; AND  
b. REVIEW OF SELECTED DESIGN DRAWINGS BY STONE AND WEBSTER ENGINEERING CO., BECHTEL, AND POTOMAC ELECTRIC POWER COMPANY (SECTION 2 OF THE REPORT LISTS THE DRAWINGS REVIEWED AND APPENDIX A OF THE REPORT PRESENTS EXAMPLE SELECTED DESIGN DRAWINGS)

ITEMS IN RED FROM FIELD RUN SURVEY BY DEWBERRY & DAVIS OBTAINED 28 AUGUST 2014.

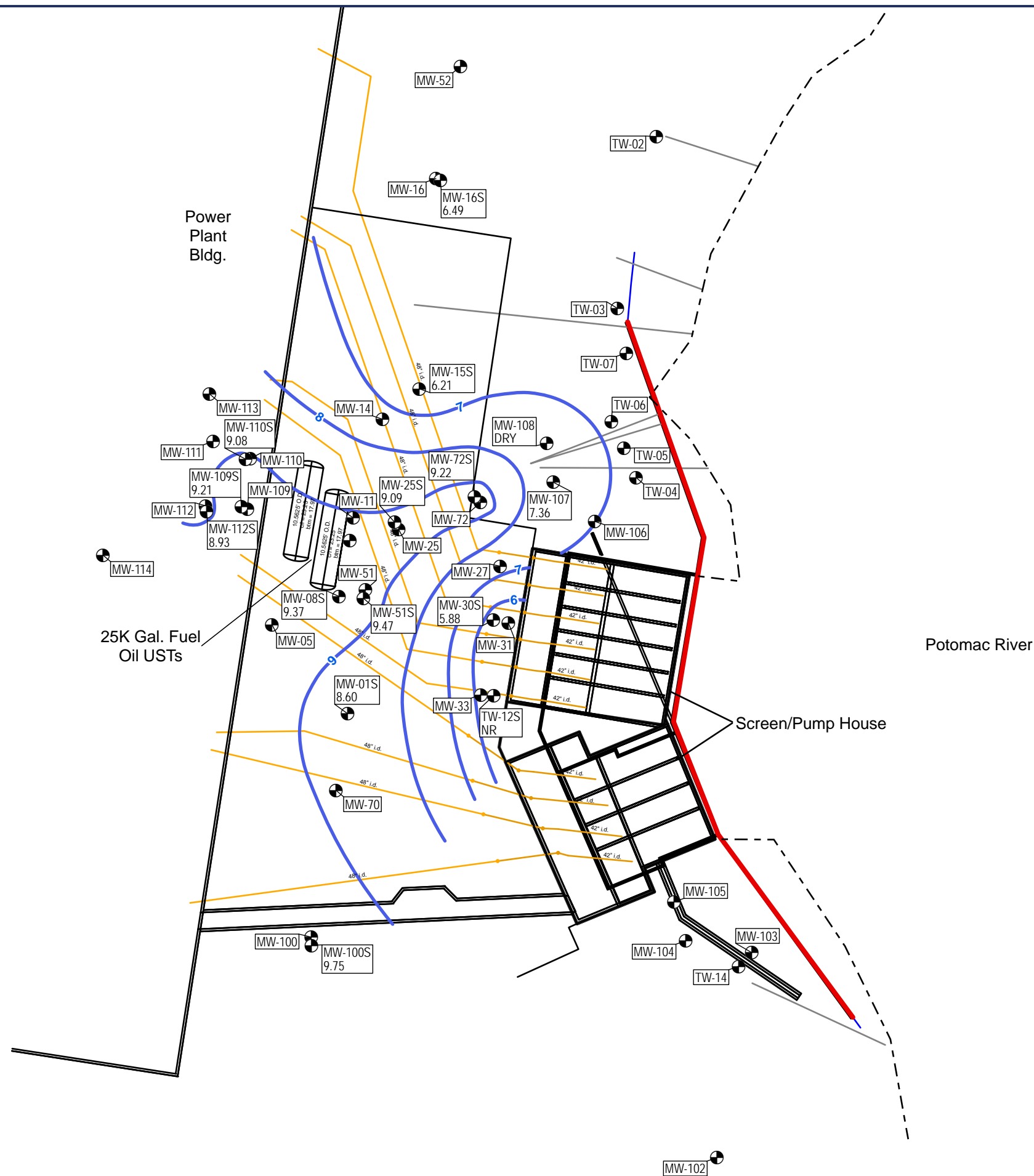
FOR INFORMATION ONLY

REV	DATE	DESCRIPTION			DRN
BY: <b>GESyntec</b> consultants 10220 OLD COLUMBIA ROAD, SUITE A COLUMBIA, MARYLAND 21046 USA PHONE: 410.381.4333		AND	FOR: <b>GESM</b> <b>nrg</b> The power to change life.		
TITLE: SITE PLAN AND SECTIONS					
PROJECT: SITE INVESTIGATION					
SITE: POTOMAC RIVER GENERATING STATION ALEXANDRIA, VIRGINIA					
THIS DRAWING MAY NOT BE ISSUED FOR PROJECT TENDER OR CONSTRUCTION, UNLESS SEALED.  _____ SIGNATURE  _____ DATE		DESIGN BY:	JOC	DATE:	SEPTEMBER 2014
		DRAWN BY:	JOC	PROJECT NO.:	MEM1108
		CHECKED BY:	MAH	FILE:	1108-003
		REVIEWED BY:	MAJ	FIGURE NO.:	7
		APPROVED BY:			

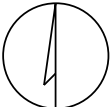

L:\Projects\GeoSyntec\PotomacPowerGenerationStation\GIS\PotomacRiverGenerationStation\_GWE\_20140825\_Shallow.mxd - Scale 1:600 - 9/4/2014 4:06:41 PM - RBannister - NAD 1983 StatePlane Virginia North FIPS 4501 Feet

Legend

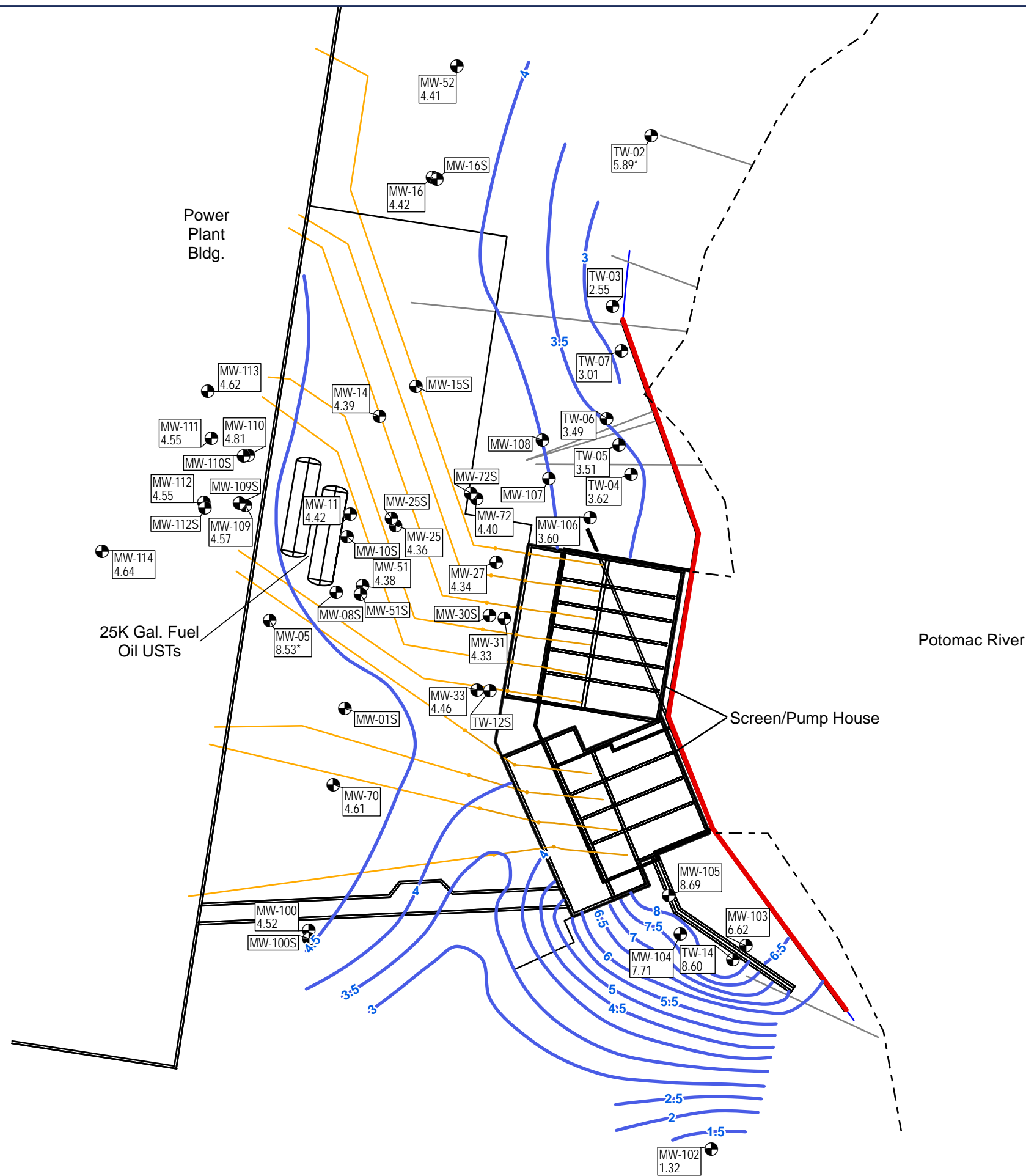
- Monitoring Wells
- Groundwater Elevation Contours  
Shallow Zone (1ft Interval)
- Property Boundary (Approximate)
- Sheet Pile Bulkhead
- Water Intake Pipes
- Outfall Pipes









Notes:  
NR = Not recorded due to lack of available water

DRAFTED BY: RAB	GROUNDWATER ELEVATION CONTOUR MAP SHALLOW ZONE, 8/25/2014		
CHECKED BY: GR	POTOMAC RIVER GENERATING STATION 1400 NORTH ROYAL STREET ALEXANDRIA, VIRGINIA		
REVIEWED BY: SS			
NORTH 	Groundwater & Environmental Services, Inc. 1350 BLAIR DRIVE, SUITE A, ODENTON, MD 21113		
	SCALE IN FEET 	DATE 9-4-14	FIGURE 8

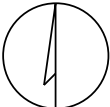

L:\Projects\GeoSyntec\PotomacPowerGenerationStation\GIS\PotomacRiverGenerationStation\_GWE\_20140825\_Deep.mxd - Scale 1:600 - 9/4/2014 4:09:40 PM - RBannister - NAD 1983 StatePlane Virginia North FIPS 4501 Feet



**Legend**

-  Monitoring Wells
-  Groundwater Elevation Contours  
Deep Zone (0.5 ft Interval)
-  Property Boundary (Approximate)
-  Sheet Pile Bulkhead
-  Water Intake Pipes
-  Outfall Pipes

Notes:  
\* = Elevation value not contoured

DRAFTED BY: RAB	GROUNDWATER ELEVATION CONTOUR MAP DEEP ZONE, 8/25/2014		
CHECKED BY: GR	POTOMAC RIVER GENERATING STATION 1400 NORTH ROYAL STREET ALEXANDRIA, VIRGINIA		
REVIEWED BY: SS			
NORTH 	Groundwater & Environmental Services, Inc. 1350 BLAIR DRIVE, SUITE A, ODENTON, MD 21113		
	SCALE IN FEET  0 50	DATE 9-4-14	FIGURE 9



Geosyntec  
consultants

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## **TABLES**

Table 1

**HISTORICAL MONITORING WELL GAUGING DATA SUMMARY**

Potomac River Generating Station  
1400 North Royal St  
Alexandria, VA

Monitoring Well	Date	Top of Casing (ft)	Depth to Water (ft)	GW Elevation (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Volume of LNAPL Recovered (Gallons)	Depth to Bottom - Measured Depth (feet)
TW-01	12/18/2013	38.31	31.38	6.93	-	-	-	-
	01/08/2014		31.80	6.51	31.79	0.01	-	-
	03/07/2014		30.41	7.90	-	-	-	-
	03/13/2014		31.13	7.18	-	-	-	-
	03/20/2014		30.36	7.95	-	-	-	-
	03/27/2014		31.22	7.09	-	-	-	-
	04/03/2014		30.36	7.95	-	-	-	-
	04/08/2014		30.21	8.10	-	-	-	-
	04/17/2014		31.02	7.29	-	-	-	-
	04/22/2014		30.18	7.13	-	-	-	-
	04/29/2014		30.22	7.08	-	-	-	-
	05/05/2014		30.29	7.01	-	-	-	-
	05/12/2014		30.28	7.02	-	-	-	-
	05/19/2014		30.16	7.14	-	-	-	-
	06/02/2014		30.17	7.13	-	-	-	-
	06/09/2014		30.08	7.22	-	-	-	-
	06/16/2014		30.23	7.07	-	-	-	-
	06/23/2014		30.02	8.29	-	-	-	-
	07/02/2014		29.98	8.33	-	-	-	-
	07/07/2014		30.16	8.15	-	-	-	34.52
	07/14/2014		29.89	8.42	-	-	-	-
	07/31/2014		30.26	8.05	-	-	-	34.50
	08/01/2014		Overdrilled and replaced with MW-05					
TW-02	12/18/2013	20.60	15.52	5.08	-	-	-	-
	01/08/2014		15.08	5.52	-	-	-	-
	03/07/2014		14.81	5.79	-	-	-	-
	03/13/2014		14.22	6.38	-	-	-	-
	03/20/2014		13.39	7.21	-	-	-	-
	03/27/2014		14.31	6.29	-	-	-	-
	04/03/2014		13.25	7.35	-	-	-	-
	04/08/2014		13.74	6.86	-	-	-	-
	04/17/2014		13.70	6.90	-	-	-	-
	04/22/2014		13.62	6.98	-	-	-	-
	04/29/2014		13.96	6.64	-	-	-	-
	05/05/2014		13.55	7.05	-	-	-	-
	05/12/2014		14.25	6.35	-	-	-	-
	05/19/2014		13.63	6.97	-	-	-	-
	05/27/2014		14.31	6.29	-	-	-	-
	06/02/2014		14.34	6.26	-	-	-	-
	06/09/2014		14.71	5.89	-	-	-	-
	06/16/2014		14.30	6.30	-	-	-	-
	06/23/2014		14.48	6.12	-	-	-	-
	07/02/2014		14.77	5.83	-	-	-	-
	07/07/2014		15.08	5.52	-	-	-	21.28
	07/14/2014		15.02	5.58	-	-	-	-

Table 1

**HISTORICAL MONITORING WELL GAUGING DATA SUMMARY**

Potomac River Generating Station  
1400 North Royal St  
Alexandria, VA

Monitoring Well	Date	Top of Casing (ft)	Depth to Water (ft)	GW Elevation (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Volume of LNAPL Recovered (Gallons)	Depth to Bottom - Measured Depth (feet)
TW-02 (cont.)	07/31/2014		15.40	5.20	-	-	-	21.22
	08/08/2014		15.40	5.20	-	-	-	-
	08/11/2014		15.28	5.32	-	-	-	-
	08/15/2014		14.84	5.76	-	-	-	21.15
	08/18/2014		15.06	5.54	-	-	-	-
	08/25/2014		14.71	5.89	-	-	-	-
TW-03	12/18/2013	14.87	9.08	5.79	-	-	-	-
	01/08/2014		9.42	5.45	-	-	-	-
	03/07/2014		7.66	7.21	-	-	-	-
	03/13/2014		8.09	6.78	-	-	-	-
	03/20/2014		7.50	7.37	-	-	-	-
	03/27/2014		8.47	6.40	-	-	-	-
	04/03/2014		6.99	7.88	-	-	-	-
	04/08/2014		7.64	7.23	-	-	-	-
	04/17/2014		7.33	7.54	-	-	-	-
	04/22/2014		7.64	7.23	-	-	-	-
	04/29/2014		7.36	7.51	-	-	-	-
	05/05/2014		7.58	7.29	-	-	-	-
	05/12/2014		7.93	6.94	-	-	-	-
	05/19/2014		8.42	6.45	-	-	-	-
	05/27/2014		7.69	7.18	-	-	-	-
	06/02/2014		8.00	6.87	-	-	-	-
	06/09/2014		7.77	7.10	-	-	-	-
	06/16/2014		7.60	7.27	-	-	-	-
	06/23/2014		7.68	7.19	-	-	-	-
	07/02/2014		7.97	6.90	-	-	-	-
	07/07/2014		8.31	6.56	-	-	-	13.45
	07/14/2014		7.55	7.32	-	-	-	-
	07/25/2014		8.45	6.42	-	-	-	13.30
	07/31/2014		8.14	6.73	-	-	-	13.35
	08/08/2014		8.39	6.48	-	-	-	-
	08/11/2014		8.12	6.75	-	-	-	-
	08/15/2014		8.10	6.77	-	-	-	13.40
	08/18/2014		8.25	6.62	-	-	-	-
	08/25/2014	10.40	7.85	2.55	-	-	-	-
TW-04	12/18/2013	13.26	6.25	7.01	-	-	-	-
	01/08/2014		6.71	6.55	-	-	-	-
	03/07/2014		6.06	7.20	-	-	-	-
	03/13/2014		6.26	7.00	-	-	-	-
	03/20/2014		6.17	7.09	-	-	-	-
	03/27/2014		6.55	6.71	-	-	-	-
	04/03/2014		4.64	8.62	-	-	-	-
	04/08/2014		5.38	7.88	-	-	-	-
	04/17/2014		5.60	7.66	-	-	-	-

Table 1

# HISTORICAL MONITORING WELL GAUGING DATA SUMMARY

Potomac River Generating Station  
1400 North Royal St  
Alexandria, VA

Monitoring Well	Date	Top of Casing (ft)	Depth to Water (ft)	GW Elevation (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Volume of LNAPL Recovered (Gallons)	Depth to Bottom - Measured Depth (feet)
TW-04 (cont.)	04/22/2014	9.49	5.56	7.70	-	-	-	-
	04/29/2014		5.91	7.35	-	-	-	-
	05/05/2014		5.06	8.20	-	-	-	-
	05/12/2014		5.82	7.44	-	-	-	-
	05/19/2014		4.61	8.65	-	-	-	-
	05/27/2014		5.66	7.60	-	-	-	-
	06/02/2014		5.83	7.43	-	-	-	-
	06/09/2014		5.87	7.39	-	-	-	-
	06/16/2014		5.21	8.05	-	-	-	-
	06/23/2014		5.68	7.58	-	-	-	-
	07/02/2014		5.96	7.30	-	-	-	-
	07/07/2014		6.18	7.08	-	-	-	13.77
	07/14/2014		5.80	7.46	-	-	-	-
	07/25/2014		6.20	7.06	-	-	-	13.70
	07/31/2014		6.08	7.18	-	-	-	13.76
	08/08/2014		6.21	7.05	-	-	-	-
	08/11/2014		6.19	7.07	-	-	-	-
	08/15/2014		5.99	7.27	-	-	-	13.75
	08/18/2014		5.92	7.34	-	-	-	-
	08/25/2014		5.87	3.62	-	-	-	-
TW-05	12/18/2013	13.73	6.45	7.28	-	-	-	-
	01/08/2014		6.98	6.75	-	-	-	-
	03/07/2014		6.34	7.39	-	-	-	-
	03/13/2014		6.49	7.24	-	-	-	-
	03/20/2014		6.04	7.69	-	-	-	-
	03/27/2014		6.68	7.05	-	-	-	-
	04/03/2014		4.29	9.44	-	-	-	-
	04/08/2014		5.36	8.37	-	-	-	-
	04/17/2014		5.33	8.40	-	-	-	-
	04/22/2014		5.65	8.08	-	-	-	-
	04/29/2014		6.06	7.67	-	-	-	-
	05/05/2014		4.91	8.82	-	-	-	-
	05/12/2014		6.01	7.72	-	-	-	-
	05/19/2014		4.65	9.08	-	-	-	-
	05/27/2014		5.91	7.82	-	-	-	-
	06/02/2014		6.07	7.66	-	-	-	-
	06/09/2014		6.11	7.62	-	-	-	-
	06/16/2014		5.28	8.45	-	-	-	-
	06/23/2014		5.95	7.78	-	-	-	-
	07/02/2014		6.28	7.45	-	-	-	-
	07/07/2014		6.49	7.24	-	-	-	12.06
	07/14/2014		6.06	7.67	-	-	-	-
	07/25/2014		5.43	8.30	-	-	-	12.08
	07/31/2014		6.50	7.23	-	-	-	12.10
	08/08/2014		6.56	7.17	-	-	-	-

Table 1

**HISTORICAL MONITORING WELL GAUGING DATA SUMMARY**

Potomac River Generating Station  
1400 North Royal St  
Alexandria, VA

Monitoring Well	Date	Top of Casing (ft)	Depth to Water (ft)	GW Elevation (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Volume of LNAPL Recovered (Gallons)	Depth to Bottom - Measured Depth (feet)
TW-05 (cont.)	08/11/2014	9.64	6.51	7.22	-	-	-	-
	08/15/2014		5.91	7.82	-	-	-	11.95
	08/18/2014		6.14	7.59	-	-	-	-
	08/25/2014		6.13	3.51	-	-	-	-
TW-06	12/18/2013	13.97	6.21	7.76	-	-	-	-
	01/08/2014		6.98	6.99	-	-	-	-
	03/07/2014		6.40	7.57	-	-	-	-
	03/13/2014		6.62	7.35	-	-	-	-
	03/20/2014		6.26	7.71	-	-	-	-
	03/27/2014		6.88	7.09	-	-	-	-
	04/03/2014		4.81	9.16	-	-	-	-
	04/08/2014		5.82	8.15	-	-	-	-
	04/17/2014		5.41	8.56	-	-	-	-
	04/22/2014		5.90	8.07	-	-	-	-
	04/29/2014		6.30	7.67	-	-	-	-
	05/05/2014		4.98	8.99	-	-	-	-
	05/12/2014		6.18	7.79	-	-	-	-
	05/19/2014		4.63	9.34	-	-	-	-
	05/27/2014		6.79	7.18	-	-	-	-
	06/02/2014		6.24	7.73	-	-	-	-
	06/09/2014		6.31	7.66	-	-	-	-
	06/16/2014		5.33	8.64	-	-	-	-
	06/23/2014		6.12	7.85	-	-	-	-
	07/02/2014		6.52	7.45	-	-	-	-
	07/07/2014		6.70	7.27	-	-	-	12.60
	07/14/2014		6.24	7.73	-	-	-	-
	07/25/2014		6.65	7.32	-	-	-	12.60
	08/08/2014		6.81	7.16	-	-	-	-
	08/11/2014		6.71	7.26	-	-	-	-
	08/15/2014		6.01	7.96	-	-	-	12.70
	08/18/2014		6.33	7.64	-	-	-	-
	08/25/2014	9.86	6.37	3.49	-	-	-	-
TW-07	12/18/2013	14.00	7.56	6.44	-	-	-	-
	01/08/2014		7.91	6.09	-	-	-	-
	03/07/2014		6.91	7.09	-	-	-	-
	03/13/2014		7.40	6.60	-	-	-	-
	03/20/2014		6.78	7.22	-	-	-	-
	03/27/2014		7.56	6.44	-	-	-	-
	04/03/2014		5.67	8.33	-	-	-	-
	04/08/2014		6.77	7.23	-	-	-	-
	04/17/2014		5.51	8.49	-	-	-	-
	04/22/2014		6.75	7.25	-	-	-	-
	04/29/2014		6.60	7.40	-	-	-	-
	05/05/2014		5.41	8.59	-	-	-	-

Table 1

**HISTORICAL MONITORING WELL GAUGING DATA SUMMARY**

Potomac River Generating Station  
1400 North Royal St  
Alexandria, VA

Monitoring Well	Date	Top of Casing (ft)	Depth to Water (ft)	GW Elevation (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Volume of LNAPL Recovered (Gallons)	Depth to Bottom - Measured Depth (feet)
TW-07 (cont.)	05/12/2014	9.88	6.89	7.11	-	-	-	-
	05/19/2014		6.16	7.84	-	-	-	-
	05/27/2014		6.70	7.30	-	-	-	-
	06/02/2014		6.94	7.06	-	-	-	-
	06/09/2014		7.81	6.19	-	-	-	-
	06/16/2014		6.47	7.53	-	-	-	-
	06/23/2014		6.69	7.31	-	-	-	-
	07/02/2014		7.00	7.00	-	-	-	-
	07/07/2014		7.27	6.73	-	-	-	13.42
	07/14/2014		6.70	7.30	-	-	-	-
	07/25/2014		7.33	6.67	-	-	-	13.30
	07/31/2014		7.22	6.78	-	-	-	13.30
	08/08/2014		7.39	6.61	-	-	-	-
	08/11/2014		7.17	6.83	-	-	-	13.20
	08/15/2014		7.05	6.95	-	-	-	-
	08/18/2014		7.14	6.86	-	-	-	-
	08/25/2014		6.87	3.01	-	-	-	-
TW-08S	12/18/2013	36.75	DRY	-	-	-	-	-
	01/08/2014		DRY	-	-	-	-	-
	03/07/2014		24.14	12.61	-	-	-	-
	03/13/2014		24.06	12.69	-	-	-	-
	03/20/2014		24.37	12.38	-	-	-	-
	03/27/2014		24.54	12.21	-	-	-	-
	04/03/2014		24.26	12.49	-	-	-	-
	04/08/2014		23.85	12.90	-	-	-	-
	04/17/2014		24.13	12.62	-	-	-	-
	04/22/2014		23.92	12.83	-	-	-	-
	04/29/2014		23.91	12.84	-	-	-	-
	05/05/2014		22.89	13.86	-	-	-	-
	05/12/2014		23.02	13.73	-	-	-	-
	05/19/2014		22.90	13.85	-	-	-	-
	06/02/2014		23.24	13.51	-	-	-	-
	06/09/2014		23.21	13.54	-	-	-	-
	06/16/2014		22.40	14.35	-	-	-	-
	06/23/2014		22.41	14.34	-	-	-	-
	07/02/2014		22.40	14.35	-	-	-	-
	07/07/2014		22.65	14.10	-	-	-	25.85
	07/14/2014		23.23	13.52	-	-	-	-
	07/24/2014		23.09	13.66	-	-	-	-
	07/31/2014		23.26	13.49	-	-	-	25.82
	08/07/2014		Overdrilled and replaced with MW-72S					
TW-09S	12/18/2013	36.65	DRY	-	-	-	-	-
	01/08/2014		DRY	-	25.54	0.46	0.10	-
	03/07/2014		24.71	11.94	24.70	0.01	-	-

Table 1

# HISTORICAL MONITORING WELL GAUGING DATA SUMMARY

Potomac River Generating Station  
1400 North Royal St  
Alexandria, VA

Monitoring Well	Date	Top of Casing (ft)	Depth to Water (ft)	GW Elevation (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Volume of LNAPL Recovered (Gallons)	Depth to Bottom - Measured Depth (feet)
TW-09S (cont.)	03/13/2014		25.78	10.87	24.71	1.07	0.10	-
	03/20/2014		DRY	-	25.65	0.50	0.10	-
	03/27/2014		DRY	-	25.58	0.54	0.10	-
	04/03/2014		23.37	13.28	23.18	0.19	0.10	-
	04/08/2014		23.39	13.26	23.23	0.16	0.10	-
	04/17/2014		23.72	12.93	23.66	0.06	-	-
	04/22/2014		23.53	13.12	23.40	0.13	0.10	-
	04/29/2014		23.76	12.89	23.68	0.08	-	-
	05/05/2014		23.23	13.42	23.17	0.06	-	-
	05/12/2014		23.25	13.40	23.23	0.02	-	-
	05/19/2014		23.17	13.48	23.16	0.01	-	-
	06/02/2014		23.19	13.46	-	-	-	-
	06/09/2014		23.17	13.48	-	-	-	-
	06/16/2014		23.13	13.52	-	-	-	-
	06/23/2014		23.11	13.54	-	-	-	-
	07/02/2014		23.03	13.62	SHEEN	SHEEN	-	-
	07/07/2014		23.01	13.64	-	-	-	26.15
	07/14/2014		23.02	13.63	-	-	-	-
	07/23/2014		Overdrilled and replaced with MW-08S					
TW-10	12/18/2013	37.28	30.31	6.97	-	-	-	-
	01/08/2014		30.56	6.72	-	-	-	-
	03/07/2014		29.70	7.58	-	-	-	-
	03/13/2014		30.08	7.20	-	-	-	-
	03/20/2014		29.22	8.06	-	-	-	-
	03/27/2014		30.13	7.15	-	-	-	-
	04/03/2014		29.08	8.20	-	-	-	-
	04/08/2014		29.14	8.14	-	-	-	-
	04/17/2014		29.66	7.62	-	-	-	-
	04/22/2014		29.12	8.16	-	-	-	-
	04/29/2014		28.96	8.32	-	-	-	-
	05/05/2014		29.22	8.06	-	-	-	-
	05/12/2014		29.06	8.22	-	-	-	-
	05/19/2014		29.02	8.26	-	-	-	-
	06/02/2014		28.99	8.29	-	-	-	-
	06/09/2014		28.89	8.39	-	-	-	-
	06/16/2014		29.02	8.26	-	-	-	-
	06/23/2014		28.86	8.42	-	-	-	-
	07/02/2014		28.87	8.41	-	-	-	-
	07/07/2014		29.12	8.16	-	-	-	36.47
	07/14/2014		28.68	8.60	-	-	-	-
	07/21/2014		Overdrilled and replaced with MW-27					
TW-11	12/18/2013	37.39	26.40	10.99	-	-	-	-
	01/08/2014		27.73	9.66	-	-	-	-
	03/07/2014		29.17	8.22	-	-	-	-

Table 1

**HISTORICAL MONITORING WELL GAUGING DATA SUMMARY**

Potomac River Generating Station  
1400 North Royal St  
Alexandria, VA

Monitoring Well	Date	Top of Casing (ft)	Depth to Water (ft)	GW Elevation (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Volume of LNAPL Recovered (Gallons)	Depth to Bottom - Measured Depth (feet)
TW-11 (cont.)	03/13/2014		27.56	9.83	-	-	-	-
	03/20/2014		27.15	10.24	-	-	-	-
	03/27/2014		27.40	9.99	-	-	-	-
	04/03/2014		26.28	11.11	26.26	0.02	0.10	-
	04/08/2014		26.52	10.87	-	-	-	-
	04/17/2014		26.85	10.54	-	-	-	-
	04/22/2014		27.09	10.30	-	-	-	-
	04/29/2014		27.39	10.00	-	-	-	-
	05/05/2014		26.26	11.13	26.24	0.02	-	-
	05/12/2014		26.97	10.42	-	-	-	-
	05/19/2014		25.91	11.48	25.90	0.01	-	-
	06/02/2014		26.32	11.07	26.31	0.01	-	-
	06/09/2014		25.23	12.16	-	-	-	-
	06/16/2014		25.35	12.04	25.36	0.01	-	-
	06/23/2014		26.55	10.84	-	-	-	-
	07/02/2014		26.91	10.48	SHEEN	SHEEN	-	-
	07/07/2014		27.08	10.31	-	-	-	37.10
	07/14/2014		26.95	10.44	SHEEN	SHEEN	-	-
	07/24/2014		26.88	10.51	-	-	-	-
	07/31/2014		27.10	10.29	-	-	-	37.02
	08/05/2014		Overdrilled and replaced with MW-31					
TW-12S	12/18/2013	38.01	DRY	-	-	-	-	-
	01/08/2014		DRY	-	-	-	-	-
	03/07/2014		DRY	-	-	-	-	-
	03/13/2014		DRY	-	-	-	-	-
	03/20/2014		DRY	-	-	-	-	-
	03/27/2014		DRY	-	-	-	-	-
	04/03/2014		DRY	-	-	-	-	-
	04/08/2014		DRY	-	-	-	-	-
	04/17/2014		DRY	-	-	-	-	-
	04/22/2014		DRY	-	-	-	-	-
	04/29/2014		DRY	-	-	-	-	-
	05/05/2014		DRY	-	-	-	-	-
	05/12/2014		DRY	-	-	-	-	-
	05/19/2014		DRY	-	-	-	-	-
	06/02/2014		DRY	-	-	-	-	-
	06/09/2014		DRY	-	-	-	-	-
	06/16/2014		26.37	10.02	-	-	-	-
	06/23/2014		26.37	11.64	-	-	-	-
	07/02/2014		26.40	11.61	-	-	-	-
	07/07/2014		26.40	11.61	-	-	-	26.60
	07/14/2014		26.48	11.53	-	-	-	-
	07/24/2014		26.48	11.53	-	-	-	-
	07/31/2014		26.48	11.53	-	-	-	26.56
	08/08/2014		26.49	11.52	-	-	-	26.60

Table 1

**HISTORICAL MONITORING WELL GAUGING DATA SUMMARY**

Potomac River Generating Station  
1400 North Royal St  
Alexandria, VA

Monitoring Well	Date	Top of Casing (ft)	Depth to Water (ft)	GW Elevation (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Volume of LNAPL Recovered (Gallons)	Depth to Bottom - Measured Depth (feet)
TW-12S (cont.)	08/11/2014		26.47	11.54	-	-	-	-
	08/15/2014		26.47	11.54	-	-	-	26.58
	08/18/2014		26.47	11.54	-	-	-	-
	08/25/2014		26.47	11.54	-	-	-	-
TW-13	12/18/2013	36.99	30.09	6.90	-	-	-	-
	01/08/2014		30.45	6.54	-	-	-	-
	03/07/2014		29.11	7.88	-	-	-	-
	03/13/2014		29.91	7.08	-	-	-	-
	03/20/2014		29.09	7.90	-	-	-	-
	03/27/2014		29.98	7.01	-	-	-	-
	04/03/2014		29.05	7.94	-	-	-	-
	04/08/2014		29.98	7.01	-	-	-	-
	04/17/2014		29.62	7.37	-	-	-	-
	04/22/2014		28.93	8.06	-	-	-	-
	04/29/2014		28.90	8.09	-	-	-	-
	05/05/2014		29.95	7.04	-	-	-	-
	05/12/2014		28.91	8.08	-	-	-	-
	05/19/2014		28.87	8.12	-	-	-	-
	06/02/2014		28.86	8.13	-	-	-	-
	06/09/2014		28.73	8.26	-	-	-	-
	06/16/2014		28.88	8.11	-	-	-	-
	06/23/2014		28.65	8.34	-	-	-	-
	07/02/2014		28.69	8.30	-	-	-	-
	07/07/2014		28.91	8.08	-	-	-	35.02
	07/14/2014		28.58	8.41	-	-	-	-
	07/29/2014		Overdrilled and replaced with MW-14					
TW-14	01/17/2014	15.55	2.48	13.07	-	-	-	-
	03/07/2014		2.29	13.26	-	-	-	-
	03/13/2014		2.55	13.00	-	-	-	-
	03/20/2014		2.25	13.30	-	-	-	-
	03/27/2014		2.42	13.13	-	-	-	-
	04/03/2014		2.31	13.24	-	-	-	-
	04/08/2014		2.27	13.28	-	-	-	-
	04/17/2014		2.26	13.29	-	-	-	-
	04/22/2014		2.48	13.07	-	-	-	-
	04/29/2014		2.66	12.89	-	-	-	-
	05/05/2014		2.56	12.99	-	-	-	-
	05/12/2014		2.58	12.97	-	-	-	-
	05/19/2014		2.38	13.17	-	-	-	-
	06/02/2014		2.52	13.03	-	-	-	-
	06/09/2014		2.50	13.05	-	-	-	-
	06/16/2014		2.31	13.24	-	-	-	-
	06/23/2014		2.44	13.11	-	-	-	-
	07/02/2014		4.63	10.92	-	-	-	-

Table 1

**HISTORICAL MONITORING WELL GAUGING DATA SUMMARY**

Potomac River Generating Station  
1400 North Royal St  
Alexandria, VA

Monitoring Well	Date	Top of Casing (ft)	Depth to Water (ft)	GW Elevation (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Volume of LNAPL Recovered (Gallons)	Depth to Bottom - Measured Depth (feet)
TW-14 (cont.)	07/07/2014	11.61	4.65	10.90	-	-	-	7.27
	07/14/2014		4.40	11.15	-	-	-	-
	07/24/2014		4.46	11.09	-	-	-	-
	07/31/2014		4.63	10.92	-	-	-	7.39
	08/08/2014		4.43	11.12	-	-	-	7.39
	08/11/2014		4.57	10.98	-	-	-	-
	08/15/2014		4.36	11.19	-	-	-	7.39
	08/18/2014		4.49	11.06	-	-	-	-
	08/25/2014		3.01	8.60	-	-	-	-
MW-01S	08/08/2014	30.87	22.67	-	-	-	-	26.58
	08/11/2014		22.62	-	-	-	-	-
	08/15/2014		22.60	-	-	-	-	-
	08/18/2014		22.88	-	-	-	-	-
	08/25/2014		22.27	8.60	-	-	-	-
MW-05	08/08/2014	31.57	25.41	-	-	-	-	33.94
	08/11/2014		25.16	-	-	-	-	-
	08/15/2014		24.98	-	-	-	-	-
	08/16/2014		24.84	-	24.80	0.04	NR <sup>2</sup>	-
	08/18/2014		24.88	-	24.80	0.08	NR <sup>2</sup>	-
	08/25/2014		23.27	8.30	22.99	0.28	0.06	-
MW-08S	07/24/2014	30.86	26.59	-	-	-	-	-
	07/31/2014		22.08	-	-	-	-	24.35
	08/08/2014		21.33	-	-	-	-	24.64
	08/11/2014		21.42	-	-	-	-	-
	08/15/2014		21.41	-	-	-	-	-
	08/18/2014		21.46	-	-	-	-	-
	08/25/2014		21.49	9.37	-	-	-	-
MW-10S	08/08/2014	31.24	22.40	-	-	-	-	26.51
	08/11/2014		22.41	-	-	-	-	-
	08/15/2014		22.02	-	-	-	-	-
	08/18/2014		22.03	-	-	-	-	-
	08/25/2014		22.06	9.18	-	-	-	-
MW-11	07/25/2014	30.85	26.90	-	-	-	-	33.40
	08/08/2014		26.76	-	-	-	-	34.00
	08/11/2014		26.57	-	-	-	-	-
	08/15/2014		27.15	-	-	-	-	-
	08/16/2014		26.81	-	-	-	-	34.00
	08/18/2014		26.77	-	-	-	-	-
	08/25/2014		26.43	4.42	-	-	-	-

Table 1

**HISTORICAL MONITORING WELL GAUGING DATA SUMMARY**

Potomac River Generating Station  
1400 North Royal St  
Alexandria, VA

Monitoring Well	Date	Top of Casing (ft)	Depth to Water (ft)	GW Elevation (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Volume of LNAPL Recovered (Gallons)	Depth to Bottom - Measured Depth (feet)
MW-14	07/31/2014	31.22	28.04	-	-	-	-	38.15
	08/08/2014		28.21	-	-	-	-	38.14
	08/11/2014		27.81	-	-	-	-	-
	08/15/2014		27.43	-	-	-	-	-
	08/18/2014		27.17	-	-	-	-	-
	08/25/2014		26.83	4.39	-	-	-	-
MW-15S	08/08/2014	31.03	26.11	-	-	-	-	26.20
	08/11/2014		26.11	-	-	-	-	-
	08/15/2014		24.00	-	-	-	-	-
	08/18/2014		24.67	-	-	-	-	-
	08/25/2014		24.82	6.21	-	-	-	-
MW-16S	08/15/2014	30.73	24.13	-	-	-	-	24.61
	08/16/2014		24.12	-	-	-	-	24.48
	08/18/2014		24.13	-	-	-	-	-
	08/25/2014		24.24	6.49	-	-	-	-
MW-16	08/15/2014	30.97	26.78	-	-	-	-	35.74
	08/18/2014		26.73	-	-	-	-	-
	08/25/2014		26.55	4.42	-	-	-	-
MW-25S	08/08/2014	31.07	23.64	-	-	-	-	25.80
	08/11/2014		22.35	-	-	-	-	-
	08/15/2014		21.94	-	-	-	-	-
	08/18/2014		21.95	-	-	-	-	-
	08/25/2014		21.98	9.09	-	-	-	-
MW-25	08/08/2014	31.13	27.97	-	27.60	0.37	0.08	36.69
	08/11/2014		27.61	-	27.37	0.24	NR <sup>2</sup>	-
	08/15/2014		28.11	-	28.05	0.06	NR <sup>2</sup>	-
	08/16/2014		27.81	-	27.75	0.06	NR <sup>2</sup>	-
	08/18/2014		27.94	-	27.71	0.23	NR <sup>2</sup>	-
	08/25/2014		26.89	4.24	26.74	0.15	0.05	-
MW-27	07/24/2014	31.43	27.59	-	-	-	-	-
	07/31/2014		27.58	-	-	-	-	34.47
	08/08/2014		27.69	-	-	-	-	34.46
	08/11/2014		27.33	-	-	-	-	-
	08/15/2014		27.90	-	-	-	-	-
	08/16/2014		27.65	-	-	-	-	34.48
	08/18/2014		27.62	-	-	-	-	-
	08/25/2014		27.09	4.34	-	-	-	-
MW-30S	08/08/2014		23.31	-	-	-	-	25.28
	08/11/2014		23.33	-	-	-	-	-

Table 1

**HISTORICAL MONITORING WELL GAUGING DATA SUMMARY**

Potomac River Generating Station  
1400 North Royal St  
Alexandria, VA

Monitoring Well	Date	Top of Casing (ft)	Depth to Water (ft)	GW Elevation (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Volume of LNAPL Recovered (Gallons)	Depth to Bottom - Measured Depth (feet)
MW-30S (cont.)	08/15/2014 08/18/2014 08/25/2014	30.67	24.84 24.84 24.79	- - 5.88	- - -	- - -	- - -	- - -
MW-31	08/08/2014 08/11/2014 08/15/2014 08/16/2014 08/18/2014 08/25/2014	31.23	27.31 26.88 27.00 26.92 27.11 26.90	- - - - - 4.33	- - - - - -	- - - - - -	- - - - - -	36.35 - - 35.00 - -
MW-33	08/08/2014 08/11/2014 08/15/2014 08/18/2014 08/25/2014	30.93	27.91 27.41 26.98 26.76 26.47	- - - - 4.46	- - - - -	- - - - -	- - - - -	35.41 - 34.45 - -
MW-51S	08/08/2014 08/11/2014 08/15/2014 08/18/2014 08/25/2014	30.81	21.15 21.27 21.17 21.23 21.34	- - - - 9.47	- - - - -	- - - - -	- - - - -	25.27 - 25.30 - -
MW-51	07/25/2014 08/08/2014 08/11/2014 08/15/2014 08/16/2014 08/18/2014 08/25/2014	30.97	27.25 27.00 26.70 27.30 26.99 26.94 26.59	- - - - - - 4.38	- SHEEN - - SHEEN SHEEN SHEEN	- SHEEN - - SHEEN SHEEN SHEEN	- - - - - - -	35.95 36.48 - - 34.65 - -
MW-52	08/15/2014 08/18/2014 08/25/2014	30.17	28.11 26.07 25.76	- - 4.41	- - -	- - -	- - -	35.78 - -
MW-70	08/15/2014 08/18/2014 08/25/2014	30.86	26.63 26.61 26.25	- - 4.61	- - -	- - -	- - -	34.95 - -
MW-72S	08/08/2014 08/11/2014 08/15/2014 08/18/2014 08/25/2014	30.63	23.33 22.85 21.35 21.34 21.41	- - - - 9.22	- - - - -	- - - - -	- - - - -	25.30 - 23.90 - -

Table 1

**HISTORICAL MONITORING WELL GAUGING DATA SUMMARY**

Potomac River Generating Station  
1400 North Royal St  
Alexandria, VA

Monitoring Well	Date	Top of Casing (ft)	Depth to Water (ft)	GW Elevation (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Volume of LNAPL Recovered (Gallons)	Depth to Bottom - Measured Depth (feet)
MW-72	08/08/2014	31.06	26.97	-	-	-	-	34.55
	08/11/2014		26.85	-	-	-	-	-
	08/15/2014		27.43	-	-	-	-	-
	08/16/2014		27.05	-	-	-	-	34.43
	08/18/2014		27.00	-	-	-	-	-
	08/25/2014		26.66	4.40	-	-	-	-
MW-100S	08/15/2014	31.06	21.32	-	-	-	-	24.22
	08/18/2014		21.28	-	-	-	-	-
	08/25/2014		21.31	9.75	-	-	-	-
MW-100	08/15/2014	30.78	26.80	-	-	-	-	36.90
	08/18/2014		26.66	-	-	-	-	-
	08/25/2014		26.26	4.52	-	-	-	-
MW-102	08/15/2014	29.72	29.91	-	-	-	-	36.64
	08/18/2014		29.81	-	-	-	-	-
	08/25/2014		28.40	1.32	-	-	-	-
MW-103	07/24/2014	11.07	7.87	-	-	-	-	-
	08/08/2014		4.61	-	-	-	-	15.06
	08/11/2014		4.63	-	-	-	-	-
	08/15/2014		4.26	-	-	-	-	14.95
	08/18/2014		4.48	-	-	-	-	-
	08/25/2014		4.45	6.62	-	-	-	-
MW-104	07/24/2014	12.00	5.24	-	-	-	-	-
	08/08/2014		4.28	-	-	-	-	12.05
	08/11/2014		4.40	-	-	-	-	-
	08/15/2014		3.95	-	-	-	-	12.20
	08/18/2014		4.22	-	-	-	-	-
	08/25/2014		4.29	7.71	-	-	-	-
MW-105	07/24/2014	10.94	2.34	-	-	-	-	-
	08/08/2014		2.15	-	-	-	-	10.06
	08/11/2014		2.39	-	-	-	-	-
	08/15/2014		1.67	-	-	-	-	9.95
	08/18/2014		2.06	-	-	-	-	-
	08/25/2014		2.25	8.69	-	-	-	-
MW-106	08/08/2014	11.12	8.30	-	-	-	-	10.27
	08/11/2014		8.27	-	-	-	-	-
	08/15/2014		7.63	-	-	-	-	9.88
	08/18/2014		7.58	-	-	-	-	-
	08/25/2014		7.52	3.60	-	-	-	-

Table 1

**HISTORICAL MONITORING WELL GAUGING DATA SUMMARY**

Potomac River Generating Station  
1400 North Royal St  
Alexandria, VA

Monitoring Well	Date	Top of Casing (ft)	Depth to Water (ft)	GW Elevation (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Volume of LNAPL Recovered (Gallons)	Depth to Bottom - Measured Depth (feet)
MW-107	08/08/2014	15.74	10.62	-	-	-	-	11.57
	08/11/2014		9.02	-	-	-	-	-
	08/15/2014		8.94	-	-	-	-	-
	08/16/2014		8.93	-	-	-	-	11.57
	08/18/2014		8.89	-	-	-	-	-
	08/25/2014		8.38	7.36	-	-	-	-
MW-108	08/08/2014	15.61	DRY	-	-	-	-	9.49
	08/11/2014		DRY	-	-	-	-	9.52
	08/15/2014		9.01	-	-	-	-	9.22
	08/18/2014		9.07	-	-	-	-	-
	08/25/2014		DRY	-	-	-	-	9.23
MW-109S	08/25/2014	19.27	10.06	9.21	-	-	-	-
MW-109	08/25/2014	19.16	14.59	4.57	-	-	-	-
MW-110S	08/25/2014	19.13	10.05	9.08	-	-	-	12.70
MW-110	08/25/2014	19.51	14.70	4.81	-	-	-	24.40
MW-111	08/25/2014	19.17	14.62	4.55	-	-	-	-
MW-112S	08/15/2014	19.22	10.31	-	-	-	-	12.40
	08/18/2014		10.22	-	-	-	-	12.45
	08/25/2014		10.29	8.93	-	-	-	-
MW-112	08/15/2014	19.08	15.11	-	-	-	-	22.55
	08/18/2014		14.43	-	-	-	-	22.31
	08/25/2014		14.53	4.55	-	-	-	-
MW-113	08/25/2014	19.11	14.49	4.62	-	-	-	-
MW-114	08/25/2014	19.26	14.62	4.64	-	-	-	22.78

- = Not available

ft = Feet

DRY = No / Insufficient water

NR<sup>1</sup> = Not recorded

NR<sup>2</sup> = Not recovered due to transducers in well

LNAPL = Non-Aqueous Petroleum Liquid

SHEEN = LNAPL thickness is less than 0.01 feet

Table 2

**WELL CONSTRUCTION DETAILS SUMMARY**

Potomac River Generating Station  
1400 North Royal St  
Alexandria, VA

Monitoring Well	Date Installed	Former URS Well	Former URS Boring Location	Well Diameter (in)	Total Depth of Well from Ground Surface (ft)	Length of Casing (ft)	Length of Screen (ft)
MW-01S	7/29/2014	-	B-01	4	27	17	10
MW-05	8/1/2014	TW-01	B-05	4	35	25	10
MW-08S	7/23/2014	TW-09S	B-08	4	25	15	10
MW-10S	7/28/2014	-	B-10	4	27	17	10
MW-11	7/24/2014	-	B-11	4	35	25	10
MW-14	7/29/2014	TW-13	B-14	4	38.5	28.5	10
MW-15S	7/31/2014	-	B-15	4	26	16	10
MW-16S	8/13/2014	-	-	2	25	15	10
MW-16	8/14/2014	-	B-16	2	36	26	10
MW-25S	8/5/2014	-	-	4	26	16	10
MW-25	7/24/2014	-	B-25	4	35	25	10
MW-27	7/21/2014	TW-10	B-27	4	35	25	10
MW-30S	8/7/2014	-	B-30	4	26	16	10
MW-31	8/5/2014	TW-11	B-31	4	36	26	10
MW-33	8/5/2014	-	B-33	4	35	25	10
MW-51S	8/6/2014	-	-	4	25.5	15.5	10
MW-51	7/22/2014	-	B-51	4	37	27	10
MW-52	8/14/2014	-	B-52	2	36	26	10
MW-70	8/13/2014	-	B-70	2	36	26	10
MW-72S	8/7/2014	TW-08S	B-72	4	25	15	10
MW-72	7/30/2014	-	B-71	4	35	25	10
MW-100S	8/12/2014	-	-	2	24.5	14.5	10
MW-100	8/12/2014	-	-	2	37.5	27.5	10
MW-102	8/11/2014	-	-	2	37	27	10
MW-103	7/23/2014	-	-	2	15	5	10
MW-104	7/24/2014	-	-	2	12	2	10

Table 2

**WELL CONSTRUCTION DETAILS SUMMARY**

Potomac River Generating Station  
1400 North Royal St  
Alexandria, VA

Monitoring Well	Date Installed	Former URS Well	Former URS Boring Location	Well Diameter (in)	Total Depth of Well from Ground Surface (ft)	Length of Casing (ft)	Length of Screen (ft)
MW-105	7/24/2014	-	-	2	10	1	9
MW-106	7/22/2014	-	-	2	10	3	7
MW-107	7/22/2014	-	-	2	11	3	8
MW-108	7/23/2014	-	-	2	10	4	6
MW-109S	8/20/2014	-	-	4	13.5	3.5	10
MW-109	8/19/2014	-	SB-2	4	24	14	10
MW-110S	8/20/2014	-	-	4	13	3	10
MW-110	8/20/2014	-	SB-1	4	24	14	10
MW-111	8/18/2014	-	-	2	22	12	10
MW-112S	8/12/2014	-	-	4	13	3	10
MW-112	8/12/2014	-	-	4	24	14	10
MW-113	8/19/2014	-	-	2	23	13	10
MW-114	8/21/2014	-	-	2	23	13	10
TW-02	12/12/2013	TW-02	B-56	2	24	14	10
TW-03	12/12/2013	TW-03	B-58	2	15	5	10
TW-04	12/13/2013	TW-04	B-67	2	15	5	10
TW-05	12/13/2013	TW-05	B-65	2	10	0	10
TW-06	12/13/2013	TW-06	B-63	2	15	5	10
TW-07	12/13/2013	TW-07	B-60	2	15	5	10
TW-12S	12/18/2013	TW-12S	B-34	2	25	15	10
TW-14	1/15/2014	TW-14	B-73	2	5.5	0.5	5

- = Not applicable

ft = Feet

in = Inches

Table 3

**HISTORICAL SOIL ANALYTICAL DATA SUMMARY**

Potomac River Generating Station  
1400 North Royal St  
Alexandria, VA

Monitoring Well / Boring	Sample Depth (feet)	Date	TPH-DRO (mg/kg)
MW-01S (B-01)	16.0 - 16.5	07/28/2014	266.5
	23.0 - 23.5	07/28/2014	4,079
MW-05 (B-05)	10.5 - 19	08/01/2014	<28.02
	23.5 - 24	08/01/2014	2,025
MW-08S (B-08S)	22.5 - 23.25	07/23/2014	6,730
MW-10S (B-10)	19.25 - 19.75	07/25/2014	114.4
	23.5 - 24.0	07/25/2014	3,748
MW-11 (B-11)	25.5 - 26.5	07/23/2014	<29.21
	30 - 31	07/23/2014	<29.81
MW-14 (B-14)	22 - 23	12/18/2013	1,510
	28 - 29	12/18/2013	2,490
	28.75 - 29.0	07/29/2014	2,696
	32 - 32.5	07/29/2014	<30.52
MW-15S (B-15)	24.3 - 24.6	07/31/2014	7,849
MW-16S (B-16)	23	08/13/2014	<30.18
MW-16 (B-16)	32	08/13/2014	<30.19
MW-25 (B-25)	29 - 30	07/24/2014	3,202
	31.5 - 32.5	07/24/2014	3,325
	24.5 - 25	08/04/2014	6,899
MW-27 (B-27)	23 - 24	12/17/2013	572
	29 - 30	12/17/2013	ND
	23.5 - 24	07/21/2014	3,286
	30 - 31.5	07/21/2014	<29.02
MW-30S (B-30)	19 - 20	08/07/2014	<27.97
MW-31 (B-31)	25 - 26	12/17/2013	ND
	35 - 36	12/17/2013	ND
MW-33 (B-33)	26.5 - 27.5	08/05/2014	<29.86
MW-34 (B-34)	26 - 27	12/18/2013	ND
MW-51S (B-51S)	22 - 22.75	08/06/2014	3,612
MW-51 (B-51)	23.0 - 23.5	07/22/2014	9,871
	29.5 - 29.9	07/22/2014	92,180

Table 3

**HISTORICAL SOIL ANALYTICAL DATA SUMMARY**

Potomac River Generating Station  
1400 North Royal St  
Alexandria, VA

Monitoring Well / Boring	Sample Depth (feet)	Date	TPH-DRO (mg/kg)
MW-52 (B-52)	32	08/13/2014	<30.97
MW-70 (B-70)	32	08/11/2014	<30.08
MW-72S (B-72)	22 - 23 31 - 32 23 - 23.5	12/17/2013 12/17/2013 08/06/2014	2,340 10.4 2,389
MW-72 (B-26R/B-72D)	26.5 - 26.75 32 - 33	07/30/2014 07/30/2014	2,426 <29.76
MW-100 (B-100)	24	08/11/2014	<28.33
MW-102 (B-102)	28 - 29	08/07/2014	<30.5
MW-103 (B-103)	7 - 8 9 - 10	07/23/2014 07/23/2014	53.29 <31.01
MW-104 (B-104)	4 - 5 5 - 6	07/24/2014 07/24/2014	<29.14 782.9
MW-105 (B-105)	0 - 1 7 - 8	07/23/2014 07/24/2014	<32.91 <30.96
MW-106 (B-106)	7 - 8 9 - 10	07/22/2014 07/22/2014	<28.73 692.1
MW-107 (B-107)	8 - 9 9 - 10	07/22/2014 07/22/2014	<29.39 92.35
MW-108 (B-108)	7 - 8 9 - 10	07/23/2014 07/23/2014	<26.78 <27.47
MW-109S	12.5 - 13	08/19/2014	<27.31
MW-109	17 - 17.5 23 - 23.5	08/19/2014 08/19/2014	430 <29.7
MW-110S	12.5 - 13	08/20/2014	13,160
MW-110	17 - 17.5 21 - 21.5	08/20/2014 08/20/2014	1,419 308.7
MW-111 (B-111)	9 - 10 16 - 16.5	08/13/2014 08/18/2014	<26.53 3,286
MW-112S (B-112)	12 - 12.5	08/11/2014	1,162

Table 3

**HISTORICAL SOIL ANALYTICAL DATA SUMMARY**

Potomac River Generating Station  
1400 North Royal St  
Alexandria, VA

Monitoring Well / Boring	Sample Depth (feet)	Date	TPH-DRO (mg/kg)
MW-112 (B-112)	16 - 16.5	08/11/2014	686.4
MW-113 (B-113)	14 - 15	08/18/2014	<27.9
MW-114	12 - 12.5	08/21/2014	<27.07
	16.5 - 17	08/21/2014	328.7
SB-1	5 - 7	07/19/2013	29.1
	9 - 11	07/19/2013	ND
	14 - 16	07/19/2013	41.4
	19 - 21	07/19/2013	9.56
	24 - 26	07/19/2013	ND
	28 - 30	07/19/2013	ND
SB-2	5 - 7	07/19/2013	ND
	9 - 11	07/19/2013	80.7
	14 - 16	07/19/2013	193
	19 - 21	07/19/2013	12.1
	23 - 25	07/19/2013	ND

ND = Non-detect

< = Result less than the Reporting Limit

TPH-DRO = Total petroleum hydrocarbons - diesel range organics

Table 4

**WELL DEVELOPMENT SUMMARY**

Potomac River Generating Station  
1400 North Royal St  
Alexandria, VA

Monitoring Well	Completed Development	Approximate Purged (gal)
MW-01S	8/4/2014	7
MW-05	8/7/2014	70
MW-08S	7/31/2014	15
MW-10S	7/31/2014	30
MW-11	7/29/2014	150
MW-14	8/6/2014	100
MW-15S	8/7/2014 (attempt)	DRY
MW-16S	8/15/2014	15
MW-16	8/15/2014	50
MW-25S	8/7/2014 (attempt)	DRY
MW-25	7/28/2014	210
MW-27	7/25/2014	145
MW-30S	8/14/2014	12
MW-31	8/18/2014	100
MW-33	8/14/2014	120
MW-51S	8/13/2014	NR
MW-51	7/28/2014	140
MW-52	8/15/2014	45
MW-70	8/14/2014	55
MW-72S	8/13/2014	NR
MW-72	8/6/2014	70
MW-100S	8/14/2014	40
MW-100	8/14/2014	55
MW-102	8/13/2014	30
MW-103	7/24/2014	15
MW-104	7/24/2014	15
MW-105	7/24/2014	15
MW-106	8/21/2014 (attempt)	Insufficient water
MW-107	8/21/2014 (attempt)	Insufficient water
MW-108	8/21/2014	8
MW-109S	8/20/2014	5
MW-109	8/20/2014	55
MW-110S	8/21/2014	50
MW-110	8/21/2014	50
MW-111	8/20/2014	50
MW-112S	8/19/2014	3
MW-112	8/19/2014	50
MW-113	8/21/2014	50
MW-114	8/21/2014	50

DRY = Not enough water to purge

gal = Gallons

NA = Not applicable

NR = Not recorded

Table 5

**HISTORICAL GROUNDWATER ANALYTICAL DATA SUMMARY**

Potomac River Generating Station  
1400 North Royal St  
Alexandria, VA

Monitoring Well	Date	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Total Xylenes (µg/L)	BTEX (µg/L)	Naphthalene (µg/L)	MTBE (µg/L)	TPH-DRO (µg/L)
TW-01	12/16/2013	14.3	ND	13.1	63.5	90.9	119	1.55	14,100
	07/07/2014	-	-	-	-	-	-	-	27,400
	08/01/2014	Overdrilled and replaced with MW-05							
TW-02	12/16/2013	ND	ND	ND	ND	ND	ND	0.791	584
	07/07/2014	-	-	-	-	-	-	-	<1,160
	08/15/2014	-	-	-	-	-	-	-	<600
TW-03	12/16/2013	ND	ND	ND	ND	ND	ND	ND	351
	07/07/2014	-	-	-	-	-	-	-	<1,160
	08/15/2014	-	-	-	-	-	-	-	<1,500
TW-04	12/16/2013	2.2	ND	3.45	7.11	12.76	27.7	ND	2,000
	07/07/2014	-	-	-	-	-	-	-	1,270
	08/15/2014	-	-	-	-	-	-	-	1,610
TW-05	12/16/2013	7.68	ND	62.8	40.3	110.78	240	ND	136,000
	07/07/2014	-	-	-	-	-	-	-	66,300
	08/15/2014	-	-	-	-	-	-	-	271,000
TW-06	12/16/2013	1.09	ND	20.3	7.86	29.25	174	ND	47,000
	07/07/2014	-	-	-	-	-	-	-	113,000
	08/15/2014	-	-	-	-	-	-	-	147,000
TW-07	12/16/2013	2.38	ND	0.969	ND	3.349	34	ND	3,290
	07/07/2014	-	-	-	-	-	-	-	41,500
	08/15/2014	-	-	-	-	-	-	-	19,600
TW-08S	07/07/2014	-	-	-	-	-	-	-	29,500
	08/07/2014	Overdrilled and replaced with MW-72S							
TW-09S	07/07/2014	-	-	-	-	-	-	-	2,330,000
	07/23/2014	Overdrilled and replaced with MW-08S							
TW-10	12/18/2013	2.51	ND	19.7	4.99	27.2	131	ND	3,040
	07/07/2014	-	-	-	-	-	-	-	23,400
	07/21/2014	Overdrilled and replaced with MW-27							
TW-11	12/18/2013	1.55	0.664	8.3	9.67	20.184	263	0.578	170,000
	07/07/2014	-	-	-	-	-	-	-	117,000
	08/05/2014	Overdrilled and replaced with MW-31							

Table 5

**HISTORICAL GROUNDWATER ANALYTICAL DATA SUMMARY**

Potomac River Generating Station  
1400 North Royal St  
Alexandria, VA

Monitoring Well	Date	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Total Xylenes (µg/L)	BTEX (µg/L)	Naphthalene (µg/L)	MTBE (µg/L)	TPH-DRO (µg/L)
TW-12S	07/07/2014	-	-	-	-	-	-	-	NS <sup>1</sup>
	08/15/2014	-	-	-	-	-	-	-	NS <sup>1</sup>
TW-13	12/18/2013	6.06	ND	44.5	137	187.56	239	ND	3,580
	07/07/2014	-	-	-	-	-	-	-	17,500
	07/29/2014	Overdrilled and replaced with MW-14							
TW-14	01/17/2014	ND	ND	ND	ND	ND	ND	0.536	2,290
	07/07/2014	-	-	-	-	-	-	-	16,000
	08/15/2014	-	-	-	-	-	-	-	3,900
MW-1S (B-1)	08/15/2014	-	-	-	-	-	-	-	2,670
MW-5 (B-5)	08/16/2014	-	-	-	-	-	-	-	NS <sup>2</sup>
MW-08S (B-08)	08/15/2014	-	-	-	-	-	-	-	7,540
MW-10S	08/15/2014	-	-	-	-	-	-	-	36,000
MW-11	08/16/2014	-	-	-	-	-	-	-	423
MW-14	08/15/2014	-	-	-	-	-	-	-	305
MW-15S (B-15)	08/15/2014	-	-	-	-	-	-	-	909
MW-16S	08/16/2014	-	-	-	-	-	-	-	1,720
MW-16 (B-16D)	08/15/2014	-	-	-	-	-	-	-	<300
MW-25S	08/15/2014	-	-	-	-	-	-	-	49,000
MW-25	08/13/2014	-	-	-	-	-	-	-	1,280
MW-27	08/16/2014	-	-	-	-	-	-	-	1,490
MW-30S	08/15/2014	-	-	-	-	-	-	-	7,040
MW-31	08/16/2014	-	-	-	-	-	-	-	27,200
MW-33	08/15/2014	-	-	-	-	-	-	-	440

Table 5

**HISTORICAL GROUNDWATER ANALYTICAL DATA SUMMARY**

Potomac River Generating Station  
1400 North Royal St  
Alexandria, VA

Monitoring Well	Date	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Total Xylenes (µg/L)	BTEX (µg/L)	Naphthalene (µg/L)	MTBE (µg/L)	TPH-DRO (µg/L)
MW-51S	08/15/2014	-	-	-	-	-	-	-	1,590
MW-51	08/11/2014	-	-	-	-	-	-	-	1,180
	08/13/2014	-	-	-	-	-	-	-	1,650
	08/16/2014	-	-	-	-	-	-	-	281,000
MW-52 (B-52D)	08/15/2014	-	-	-	-	-	-	-	<600
MW-70	08/15/2014	-	-	-	-	-	-	-	<153
MW-72S	08/15/2014	-	-	-	-	-	-	-	5,980
MW-72	08/11/2014	-	-	-	-	-	-	-	<300
	08/13/2014	-	-	-	-	-	-	-	1,100
	08/16/2014	-	-	-	-	-	-	-	1,340
MW-100S	08/15/2014	-	-	-	-	-	-	-	<300
MW-100	08/15/2014	-	-	-	-	-	-	-	<152
MW-102 (B-102)	08/15/2014	-	-	-	-	-	-	-	<1,500
MW-103 (B-103)	08/15/2014	-	-	-	-	-	-	-	479
MW-104 (B-104)	08/15/2014	-	-	-	-	-	-	-	1,630
MW-105 (B-105)	08/15/2014	-	-	-	-	-	-	-	<1,500
MW-106 (B-106)	08/15/2014	-	-	-	-	-	-	-	89,200
MW-107 (B-107)	08/16/2014	-	-	-	-	-	-	-	8,540
MW-108	08/15/2014	-	-	-	-	-	-	-	NS <sup>1</sup>
MW-109S	08/21/2014	-	-	-	-	-	-	-	7,500
MW-109	08/21/2014	-	-	-	-	-	-	-	<600
MW-110S	08/25/2014	-	-	-	-	-	-	-	6,630
MW-110	08/25/2014	-	-	-	-	-	-	-	<153

Table 5

**HISTORICAL GROUNDWATER ANALYTICAL DATA SUMMARY**

Potomac River Generating Station  
1400 North Royal St  
Alexandria, VA

Monitoring Well	Date	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Total Xylenes (µg/L)	BTEX (µg/L)	Naphthalene (µg/L)	MTBE (µg/L)	TPH-DRO (µg/L)
MW-111	08/21/2014	-	-	-	-	-	-	-	<600
MW-112S (B-112S)	08/15/2014	-	-	-	-	-	-	-	<1,500
MW-112 (B-112D)	08/15/2014	-	-	-	-	-	-	-	<1,500
MW-113	08/21/2014	-	-	-	-	-	-	-	<600
MW-114	08/25/2014	-	-	-	-	-	-	-	<600
SEEP-B (Wall Seep)	12/18/2013	2.09	ND	1.07	3.00	6.16	19.90	ND	989
	08/13/2014	-	-	-	-	-	-	-	320
SEEP-D	08/13/2014	-	-	-	-	-	-	-	<42

- = Not analyzed

NS<sup>1</sup> = Not sampled due to insufficient water volume

NS<sup>2</sup> = Not sampled due to presence of product

BTEX = Benzene, toluene, ethylbenzene, and total xylenes

MTBE = Methyl tert-butyl ether

TPH-DRO = Total petroleum hydrocarbons - diesel range organics

<# = Less than the Reporting Limit

ND = Not Detected

Table 6

**PUMP TEST RECOVERY WELL DATA SUMMARY**

Potomac River Generating Station  
August 11 to 15, 2014

<b>MW-51</b>							
<b>Date</b>	<b>Time</b>	<b>Cycle Counter</b>	<b>Cycles/ Minute</b>	<b>Total Flow</b>	<b>Flow Rate</b>	<b>Regulator Pressure</b>	<b>Drawdown</b>
		<b>(#)</b>	<b>(#)</b>	<b>(gallons)</b>	<b>(gpm)</b>	<b>(psi)</b>	<b>(feet)</b>
8/11/14	11:26 AM	634	18.0	0	1.8	55	0.0
	11:43 AM	940	18.0	31	1.8	55	3.0
	12:03 PM	1,289	17.4	66	1.7	55	3.3
	12:28 PM	1,740	18.0	111	1.8	55	2.1
	12:51 PM	1,740	0.0	111	0.0	55	0.2
	1:18 PM	2,160	15.6	153	1.6	55	3.3
	1:26 PM	2,160	0.0	153	0.0	55	0.5
	1:36 PM	2,315	15.5	168	1.5	55	3.1
	2:06 PM	2,853	17.7	222	1.8	55	3.4
	2:15 PM	3,006	16.9	237	1.7	55	3.3
	2:44 PM	3,494	17.0	286	1.7	55	3.4
	3:18 PM	4,080	17.3	345	1.7	55	3.6
	3:28 PM	4,255	17.2	362	1.7	55	3.7
	5:31 PM	6,362	17.1	573	1.7	55	3.8
8/12/14	10:00 AM	22,939	16.8	2,231	1.7	55	3.8
	11:24 AM	24,413	17.5	2,378	1.8	60	3.7
	12:20 PM	25,412	17.8	2,478	1.8	60	4.1
	12:41 PM	25,780	16.5	2,515	1.6	60	4.1
8/13/14	8:50 AM	45,662	16.4	4,503	1.6	60	2.9
	9:27 AM	46,243	15.9	4,561	1.6	60	2.8
	11:58 AM	48,650	15.9	4,802	1.6	60	2.7
	12:55 PM	49,555	15.8	4,892	1.6	60	3.0
	1:06 PM	49,725	15.8	4,909	1.6	60	2.8
	2:32 PM	51,085	15.9	5,045	1.6	60	3.2
	3:05 PM	51,620	16.3	5,099	1.6	70	3.4
	3:15 PM	51,785	16.0	5,115	1.6	70	3.4
8/14/14	7:07 PM	55,491	16.0	5,486	1.6	70	3.7
	9:31 AM	69,450	16.2	6,882	1.6	70	4.2
	9:58 AM	69,880	16.4	6,925	1.6	70	4.2
	10:15 AM	70,170	16.5	6,954	1.7	70	4.1
	11:04 AM	70,970	16.3	7,034	1.6	70	4.1
	12:18 PM	72,175	16.2	7,154	1.6	70	3.8
	12:43 PM	72,570	15.8	7,194	1.6	70	3.8
	1:00 PM	72,840	15.9	7,221	1.6	70	3.8
	2:33 PM	74,320	15.8	7,369	1.6	70	3.9
	4:01 PM	75,700	15.7	7,507	1.6	70	3.9
	4:37 PM	76,270	15.8	7,564	1.6	70	4.0
	5:18 AM	88,146	15.6	8,751	1.6	70	4.1
<b>Cumulative Pumping Time (hours):</b>				<b>89</b>			
<b>Average Flow Rate (gpm):</b>				<b>1.6</b>			
<b>Cumulative Flow (gallons):</b>				<b>8,751</b>			

Table 6

## PUMP TEST RECOVERY WELL DATA SUMMARY

Potomac River Generating Station  
August 11 to 15, 2014

MW-72D							
Date	Time	Cycle Counter	Cycles/Minute	Total Flow	Flow Rate	Regulator Pressure	Drawdown
		(#)	(#)	(gallons)	(gpm)	(psi)	(feet)
8/11/14	10:36 AM	402	7.6	0	0.8	55	0.0
	11:09 AM	652	7.6	25	0.8	55	5.7
	11:43 AM	810	4.6	41	0.5	55	5.7
	12:03 PM	910	5.0	51	0.5	55	5.7
	12:28 PM	1,060	6.0	66	0.6	55	5.7
	12:51 PM	1,060	0.0	66	0.0	55	1.5
	1:18 PM	1,221	6.0	82	0.6	55	5.7
	1:26 PM	1,221	0.0	82	0.0	55	3.8
	1:36 PM	1,280	5.9	88	0.6	55	5.7
	2:06 PM	1,459	5.8	106	0.6	55	5.7
	2:15 PM	1,505	5.2	110	0.5	55	5.7
	2:44 PM	1,658	5.0	126	0.5	55	5.7
	3:18 PM	1,820	4.7	142	0.5	55	5.7
	3:28 PM	1,866	4.4	146	0.4	55	5.7
	5:31 PM	2,407	4.4	201	0.4	55	5.7
8/12/14	9:42 AM	6,680	4.4	628	0.4	55	5.7
	10:15 AM	6,820	4.3	642	0.4	55	5.7
	10:29 AM	6,879	4.1	648	0.4	55	5.7
	11:24 AM	7,105	4.1	670	0.4	55	5.7
	12:20 PM	7,349	4.1	695	0.4	55	5.7
	12:41 PM	7,424	3.6	702	0.4	55	5.7
8/13/14	8:50 AM	12,053	3.8	1,165	0.4	55	5.7
	9:25 AM	12,188	3.9	1,179	0.4	55	5.7
Cumulative Pumping Time (hours):				46			
Average Flow Rate (gpm):				0.4			
Cumulative Flow (gallons):				1,179			

*Italic = Estimated reading*

Table 6

**PUMP TEST RECOVERY WELL DATA SUMMARY**

Potomac River Generating Station  
August 11 to 15, 2014

<b>MW-25D</b>							
<b>Date</b>	<b>Time</b>	<b>Cycle Counter</b>	<b>Cycles/Minute</b>	<b>Total Flow</b>	<b>Flow Rate</b>	<b>Regulator Pressure</b>	<b>Drawdown</b>
		(#)	(#)	(gallons)	(gpm)	(psi)	(feet)
8/13/14	12:15 PM	8,519	17.7	0	1.8	55	0.0
	12:21 PM	8,625	17.7	11	1.8	55	2.9
	12:32 PM	8,826	18.7	31	1.9	55	3.6
	12:36 PM	8,906	17.6	39	1.8	55	3.6
	12:48 PM	9,108	17.1	59	1.7	55	3.7
	1:01 PM	9,333	16.8	81	1.7	55	3.8
	1:09 PM	9,460	17.1	94	1.7	55	3.9
	1:22 PM	9,692	17.0	117	1.7	55	3.9
	1:42 PM	10,020	16.5	150	1.7	55	4.0
	2:18 PM	10,617	16.7	210	1.7	55	4.2
	2:28 PM	10,786	16.9	227	1.7	55	4.3
	3:05 PM	11,410	16.7	289	1.7	70	4.7
	3:15 PM	11,570	16.6	305	1.7	70	3.8
	7:07 PM	15,419	16.6	690	1.7	70	5.1
8/14/14	9:31 AM	30,430	17.4	2,191	1.7	70	5.3
	9:58 AM	30,880	17.0	2,236	1.7	70	5.3
	10:15 AM	31,180	17.4	2,266	1.7	70	5.2
	11:04 AM	32,030	17.4	2,351	1.7	70	5.1
	12:18 PM	33,321	17.4	2,480	1.7	70	5.0
	12:43 PM	33,750	17.2	2,523	1.7	70	5.1
	1:00 PM	34,045	17.4	2,553	1.7	70	5.1
	2:33 PM	35,666	17.4	2,715	1.7	70	5.2
	4:01 PM	37,200	17.3	2,868	1.7	70	5.2
	4:37 PM	37,815	17.1	2,930	1.7	70	5.2
8/15/14	5:18 AM	50,920	17.2	4,240	1.7	70	5.3
<b>Cumulative Pumping Time (hours):</b>				<b>41</b>			
<b>Average Flow Rate (gpm):</b>				<b>1.7</b>			
<b>Cumulative Flow (gallons):</b>				<b>4,240</b>			

Table 7

# PUMP TEST WELL GAUGING DATA SUMMARY

Potomac River Generating Station  
1400 North Royal St  
Alexandria, VA

Monitoring Well	Date	Top of Casing (ft)	Depth to Water (ft)	GW Elevation (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Volume of LNAPL Recovered (Gallons)	Depth to Bottom - Measured Depth (feet)
TW-02	08/08/2014	20.60	15.40	5.20	-	-	-	-
	08/11/2014		15.28	5.32	-	-	-	-
	08/15/2014		14.84	5.76	-	-	-	21.15
	08/18/2014		15.06	5.54	-	-	-	-
TW-03	08/08/2014	14.87	8.39	6.48	-	-	-	-
	08/11/2014		8.12	6.75	-	-	-	-
	08/15/2014		8.10	6.77	-	-	-	13.40
	08/18/2014		8.25	6.62	-	-	-	-
TW-04	08/08/2014	13.26	6.21	7.05	-	-	-	-
	08/11/2014		6.19	7.07	-	-	-	-
	08/15/2014		5.99	7.27	-	-	-	13.75
	08/18/2014		5.92	7.34	-	-	-	-
TW-05	08/08/2014	13.73	6.56	7.17	-	-	-	-
	08/11/2014		6.51	7.22	-	-	-	-
	08/15/2014		5.91	7.82	-	-	-	11.95
	08/18/2014		6.14	7.59	-	-	-	-
TW-06	08/08/2014	13.97	6.81	7.16	-	-	-	-
	08/11/2014		6.71	7.26	-	-	-	-
	08/15/2014		6.01	7.96	-	-	-	12.70
	08/18/2014		6.33	7.64	-	-	-	-
TW-07	08/08/2014	14.00	7.39	6.61	-	-	-	-
	08/11/2014		7.17	6.83	-	-	-	-
	08/15/2014		7.05	6.95	-	-	-	13.20
	08/18/2014		7.14	6.86	-	-	-	-
TW-12S	08/08/2014	38.01	26.49	11.52	-	-	-	26.60
	08/11/2014		26.47	11.54	-	-	-	-
	08/15/2014		26.47	11.54	-	-	-	26.58
	08/18/2014		26.47	11.54	-	-	-	-
TW-14	08/08/2014	15.55	4.43	11.12	-	-	-	7.39
	08/11/2014		4.57	10.98	-	-	-	-
	08/15/2014		4.36	11.19	-	-	-	7.39
	08/18/2014		4.49	11.06	-	-	-	-
MW-01S	08/08/2014		22.67	-	-	-	-	26.58
	08/11/2014		22.62	-	-	-	-	-
	08/12/2014		22.57	-	-	-	-	-
	08/13/2014		22.48	-	-	-	-	26.60

Table 7

# **PUMP TEST WELL GAUGING DATA SUMMARY**

Potomac River Generating Station  
1400 North Royal St  
Alexandria, VA

Monitoring Well	Date	Top of Casing (ft)	Depth to Water (ft)	GW Elevation (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Volume of LNAPL Recovered (Gallons)	Depth to Bottom - Measured Depth (feet)
MW-01S (cont.)	08/15/2014		22.60	-	-	-	-	-
	08/18/2014		22.88	-	-	-	-	-
MW-05	08/08/2014		25.41	-	-	-	-	33.94
	08/11/2014		25.16	-	-	-	-	-
	08/12/2014		25.13	-	-	-	-	-
	08/13/2014		25.04	-	-	-	-	-
	08/15/2014		24.98	-	-	-	-	-
	08/16/2014		24.84	-	24.80	0.04	NR	-
	08/18/2014		24.88	-	24.80	0.08	NR	-
MW-08S	08/08/2014		21.33	-	-	-	-	24.64
	08/11/2014		21.42	-	-	-	-	-
	08/12/2014		21.44	-	-	-	-	-
	08/13/2014		21.35	-	-	-	-	24.69
	08/15/2014		21.41	-	-	-	-	-
	08/18/2014		21.46	-	-	-	-	-
MW-10S	08/08/2014		22.40	-	-	-	-	26.51
	08/11/2014		22.41	-	-	-	-	-
	08/12/2014		22.41	-	-	-	-	-
	08/13/2014		22.02	-	-	-	-	26.11
	08/15/2014		22.02	-	-	-	-	-
	08/18/2014		22.03	-	-	-	-	-
MW-11	08/08/2014		26.76	-	-	-	-	34.00
	08/11/2014		26.57	-	-	-	-	-
	08/12/2014		26.80	-	-	-	-	-
	08/13/2014		26.66	-	-	-	-	-
	08/15/2014		27.15	-	-	-	-	-
	08/16/2014		26.81	-	-	-	-	34.00
	08/18/2014		26.77	-	-	-	-	-
MW-14	08/08/2014		28.21	-	-	-	-	38.14
	08/11/2014		27.81	-	-	-	-	-
	08/12/2014		27.80	-	-	-	-	-
	08/13/2014		26.80	-	-	-	-	37.29
	08/15/2014		27.43	-	-	-	-	-
	08/18/2014		27.17	-	-	-	-	-
MW-15S	08/08/2014		26.11	-	-	-	-	26.20
	08/11/2014		26.11	-	-	-	-	-
	08/15/2014		24.00	-	-	-	-	-
	08/18/2014		24.67	-	-	-	-	-

Table 7

# PUMP TEST WELL GAUGING DATA SUMMARY

Potomac River Generating Station  
1400 North Royal St  
Alexandria, VA

Monitoring Well	Date	Top of Casing (ft)	Depth to Water (ft)	GW Elevation (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Volume of LNAPL Recovered (Gallons)	Depth to Bottom - Measured Depth (feet)
MW-16S	08/15/2014		24.13	-	-	-	-	24.61
	08/16/2014		24.12	-	-	-	-	24.48
	08/18/2014		24.13	-	-	-	-	-
MW-16	08/15/2014		26.78	-	-	-	-	35.74
	08/18/2014		26.73	-	-	-	-	-
MW-25S	08/08/2014		23.64	-	-	-	-	25.80
	08/11/2014		22.35	-	-	-	-	-
	08/12/2014		22.32	-	-	-	-	-
	08/13/2014		21.92	-	-	-	-	25.45
	08/15/2014		21.94	-	-	-	-	-
	08/18/2014		21.95	-	-	-	-	-
MW-25	08/08/2014		27.97	-	27.60	0.37	0.08	36.69
	08/11/2014		27.61	-	27.37	0.24	NR	-
	08/12/2014		27.93	-	27.59	0.34	NR	-
	8/13/2014 12:03 PM		27.80	-	27.47	0.33	NR	-
	8/13/2014 12:45 PM		31.37		31.15	0.22	NR	-
	8/13/2014 2:25 PM		32.00		31.57	0.43	NR	-
	8/14/2014 10:06 AM		32.68		32.67	0.01	NR	-
	8/14/2014 1:00 PM		32.77		32.53	0.24	NR	-
	8/14/2014 3:25 PM		32.70		32.60	0.10	NR	-
	08/15/2014		28.11	-	28.05	0.06	NR	-
	08/16/2014		27.81	-	27.75	0.06	NR	-
	08/18/2014		27.94	-	27.71	0.23	NR	-
MW-27	07/24/2014		27.59	-	-	-	-	-
	07/31/2014		27.58	-	-	-	-	34.47
	08/08/2014		27.69	-	-	-	-	34.46
	08/11/2014		27.33	-	-	-	-	-
	08/12/2014		27.40	-	-	-	-	-
	08/13/2014		27.27	-	-	-	-	-
	08/15/2014		27.90	-	-	-	-	-
	08/16/2014		27.65	-	-	-	-	34.48
	08/18/2014		27.62	-	-	-	-	-
MW-30S	08/08/2014		23.31	-	-	-	-	25.28
	08/11/2014		23.33	-	-	-	-	-
	08/12/2014		23.37	-	-	-	-	-
	08/13/2014		24.24	-	-	-	-	-
	08/14/2014		24.21	-	-	-	-	-
	08/15/2014		24.84	-	-	-	-	-
	08/18/2014		24.84	-	-	-	-	-

Table 7

## PUMP TEST WELL GAUGING DATA SUMMARY

Potomac River Generating Station  
1400 North Royal St  
Alexandria, VA

Monitoring Well	Date	Top of Casing (ft)	Depth to Water (ft)	GW Elevation (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Volume of LNAPL Recovered (Gallons)	Depth to Bottom - Measured Depth (feet)
MW-31	08/08/2014		27.31	-	-	-	-	36.35
	08/11/2014		26.88	-	-	-	-	-
	08/12/2014		26.89	-	-	-	-	-
	08/13/2014		25.98	-	-	-	-	-
	08/15/2014		27.00	-	-	-	-	-
	08/16/2014		26.92	-	-	-	-	35.00
	08/18/2014		27.11	-	-	-	-	-
MW-33	08/08/2014		27.91	-	-	-	-	35.41
	08/11/2014		27.41	-	-	-	-	-
	08/12/2014		27.39	-	-	-	-	-
	08/13/2014		26.15	-	-	-	-	34.49
	08/15/2014		26.98	-	-	-	-	34.45
	08/18/2014		26.76	-	-	-	-	-
MW-51S	08/08/2014		21.15	-	-	-	-	25.27
	08/11/2014		21.27	-	-	-	-	-
	08/12/2014		21.28	-	-	-	-	-
	08/13/2014		21.03	-	-	-	-	25.30
	08/15/2014		21.17	-	-	-	-	25.30
	08/18/2014		21.23	-	-	-	-	-
MW-51	07/25/2014		27.25	-	-	-	-	35.95
	08/08/2014		27.00	-	SHEEN	SHEEN	-	36.48
	08/11/2014		26.70	-	-	-	-	-
	08/12/2014		30.50	-	-	-	-	-
	08/13/2014		29.47	-	SHEEN	SHEEN	-	-
	08/15/2014		27.30	-	-	-	-	-
	08/16/2014		26.99	-	SHEEN	SHEEN	-	34.65
	08/18/2014		26.94	-	SHEEN	SHEEN	-	-
MW-52	08/15/2014		28.11	-	-	-	-	35.78
	08/18/2014		26.07	-	-	-	-	-
MW-70	08/15/2014		26.63	-	-	-	-	34.95
	08/18/2014		26.61	-	-	-	-	-
MW-72S	08/08/2014		23.33	-	-	-	-	25.30
	08/11/2014		22.85	-	-	-	-	-
	08/12/2014		22.84	-	-	-	-	-
	08/13/2014		21.32	-	-	-	-	23.92
	08/14/2014		21.31	-	-	-	-	-
	08/15/2014		21.35	-	-	-	-	23.90
	08/18/2014		21.34	-	-	-	-	-

Table 7

# PUMP TEST WELL GAUGING DATA SUMMARY

Potomac River Generating Station  
1400 North Royal St  
Alexandria, VA

Monitoring Well	Date	Top of Casing (ft)	Depth to Water (ft)	GW Elevation (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Volume of LNAPL Recovered (Gallons)	Depth to Bottom - Measured Depth (feet)
MW-72	08/08/2014		26.97	-	-	-	-	34.55
	08/11/2014		26.85	-	-	-	-	-
	08/12/2014		32.45	-	-	-	-	-
	08/13/2014		32.45	-	-	-	-	-
	08/15/2014		27.43	-	-	-	-	-
	08/16/2014		27.05	-	-	-	-	34.43
	08/18/2014		27.00	-	-	-	-	-
MW-100S	08/15/2014		21.32	-	-	-	-	24.22
	08/18/2014		26.66	-	-	-	-	-
MW-100	08/15/2014		26.80	-	-	-	-	36.90
	08/18/2014		21.28	-	-	-	-	-
MW-102	08/15/2014		29.91	-	-	-	-	36.64
	08/18/2014		29.81	-	-	-	-	-
MW-103	07/24/2014		7.87	-	-	-	-	-
	08/08/2014		4.61	-	-	-	-	15.06
	08/11/2014		4.63	-	-	-	-	-
	08/15/2014		4.26	-	-	-	-	14.95
	08/18/2014		4.48	-	-	-	-	-
MW-104	07/24/2014		5.24	-	-	-	-	-
	08/08/2014		4.28	-	-	-	-	12.05
	08/11/2014		4.40	-	-	-	-	-
	08/15/2014		3.95	-	-	-	-	12.20
	08/18/2014		4.22	-	-	-	-	-
MW-105	07/24/2014		2.34	-	-	-	-	-
	08/08/2014		2.15	-	-	-	-	10.06
	08/11/2014		2.39	-	-	-	-	-
	08/15/2014		1.67	-	-	-	-	9.95
	08/18/2014		2.06	-	-	-	-	-
MW-106	08/08/2014		8.30	-	-	-	-	10.27
	08/11/2014		8.27	-	-	-	-	-
	08/12/2014		8.21	-	-	-	-	-
	08/13/2014		7.92	-	-	-	-	-
	08/15/2014		7.63	-	-	-	-	9.88
	08/18/2014		7.58	-	-	-	-	-
MW-107	08/08/2014		10.62	-	-	-	-	11.57
	08/11/2014		9.02	-	-	-	-	-
	08/12/2014		9.03	-	-	-	-	-

Table 7

# PUMP TEST WELL GAUGING DATA SUMMARY

Potomac River Generating Station  
1400 North Royal St  
Alexandria, VA

Monitoring Well	Date	Top of Casing (ft)	Depth to Water (ft)	GW Elevation (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Volume of LNAPL Recovered (Gallons)	Depth to Bottom - Measured Depth (feet)
MW-107 (cont.)	08/13/2014		8.58	-	-	-	-	-
	08/15/2014		8.94	-	-	-	-	-
	08/16/2014		8.93	-	-	-	-	11.57
	08/18/2014		8.89	-	-	-	-	-
MW-108	08/08/2014		DRY	-	-	-	-	9.49
	08/11/2014		DRY	-	-	-	-	9.52
	08/15/2014		9.01	-	-	-	-	9.22
	08/18/2014		9.07	-	-	-	-	-
MW-112S	08/15/2014		10.31	-	-	-	-	12.40
	08/18/2014		10.22	-	-	-	-	12.45
MW-112	08/15/2014		15.11	-	-	-	-	22.55
	08/18/2014		14.43	-	-	-	-	22.31

- = Not available

ft = Feet

DRY = No / Insufficient water

NR = Not recovered (transducers in well)

LNAPL = Non-Aqueous Petroleum Liquid

SHEEN = LNAPL thickness is less than 0.01 feet